DOCUMENT RESUME

ED 150 007	SE 023 774
TITLE	Operation and Maintenance of Wastewater Collection Systems: A Field Study Training Program.
INSTITUTION	California State Univ., Sacramento Dept. of Civil Engineering.
SPONS AGENCY	Environmental Protection Agency, Washington, D.C. Office of Water Programs.
PUB DATE	76
NOTE	1,711p.; For related document, see SE 023 775; Pages 1-19 ("Optical Scanning Form") and 9-55 ("What Everyone Should Know About Safety") removed prior to being shipped to EDRS due to copyright restrictions; Occasional photographs may not reproduce well
EDRS PRICE	MF-$3.00 HC-$91.77 Plus Postage.
DESCRIPTORS	Employment Qualifications; *Environmental Education; *Environmental Technicians; *Equipment Maintenance; *Independent Study; *Instructional Materials; Pollution; Public Health; Safety; Sanitation; *Water Pollution Control
IDENTIFIERS	*Waste Water Treatment

ABSTRACT

This manual was prepared by experienced wastewater collection system workers to provide a home study course to develop new qualified workers and expand the abilities of existing workers. The objective of this manual is to provide the knowledge and skills necessary for certification. Participants learn to effectively operate and maintain wastewater collection systems to reduce health hazards and prevent system failures. Each of the eleven lessons deals with a different aspect of wastewater collection systems such as: safety, inspection, pipeline cleaning, underground repair, new construction and administration. Each lesson contains discussion and review questions and is completed with an objective test. (CS)

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OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS

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a field study training program

• ENVIRONMENTAL PROTECTION AGENCY •
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SE 023 774

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This training manual has been reviewed by the Office of Water Programs Operations, U. S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the Environmental Protection Agency, California State University, Sacramento, California Water Pollution Control Association, authors of the chapters or project reviewers and directors.

OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS

A Field Study Training Program

prepared by

California State University, Sacramento
Department of Civil Engineering

in cooperation with the

California Water Pollution Control Association

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for the

Environmental Protection Agency
Office of Water Program Operations
Municipal Permits and Operations Division
Grant No. T900494

1976

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PREFACE

The purposes of this wastewater collection system home study course are

1. To develop new qualified wastewater collection system workers,
2. To expand the abilities of existing workers, permitting better service to both their employers and the public, and
3. To prepare workers for civil service and certification examinations.[1]

To provide you with the information needed to operate and to maintain wastewater collection systems as efficiently and effectively as possible, experienced wastewater collection system workers prepared the material in each chapter of this manual.

OBJECTIVES OF THIS MANUAL

Proper installations, inspections, operations, maintenance and repairs of wastewater collection, conveyance and treatment facilities have a significant impact on the operation and maintenance costs and effectiveness of these facilities. The objective of this manual is to provide wastewater collection system workers with the knowledge and skills where possible to effectively operate and to maintain collection systems, thus eliminating or reducing the following problems:

1. Health hazards caused by untreated wastewater flowing down streets and watercourses during stoppages and storms;
2. System failures that result from the lack of proper installation, inspection, preventive maintenance, surveillance and repair programs designed to protect the public's investment in these facilities;

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[1] Certification examination. An examination administered by a state or professional association that wastewater collection system workers take to indicate a level of professional competence. In many states certification of wastewater collection system workers is voluntary. Current trends indicate that more states and employers will require wastewater collection system workers to be "certified" in the future.

3. Odors from the collection system, lift stations, and treatment plants caused by collection system problems;

4. Shock loads from the clearing of stoppages that affect wastewater treatment processes;

5. Corrosion damages to equipment and structures in collection systems and treatment plants;

6. Inflow and infiltration that use a valuable portion of the capacity of the facilities;

7. Noise pollution from collection systems (noisy manhole lids) and lift stations; and

8. Complaints from the public or local officials due to the unreliability of the collection system. These complaints result from constant system failures and create a poor public image of the agency that is supposed to be managing the system.

SCOPE OF MANUAL

This manual contains information on:

1. What collection systems are expected to achieve,

2. Why wastewater collection systems must be properly operated and maintained,

3. What the collection system worker is expected to do to keep the collection system functioning as intended,

4. How to inspect and test newly constructed sewers and new and old wastewater collection systems,

5. How to locate and evaluate problems such as stoppages, leaks, odors and lift station failures,

6. Selection of procedures and equipment to correct identified problems and to minimize recurrence of problems and failures,

7. How to operate and maintain inspection and cleaning equipment,

8. Methods of selection and application of chemicals,

9. Procedures for operating, maintaining and repairing collection systems,

10. Instructions for operating, maintaining, trouble shooting and repairing collection system equipment and facilities such as lift stations,

11. Techniques for recognizing hazards and developing safe procedures, and

12. How to organize and administer the operation and maintenance of wastewater collection systems.

Material contained in this manual furnishes you with information concerning situations encountered by most collection system workers regardless of whether they are located in the North, South, East or West, at sea level or in the mountains, in either humid or arid regions. These materials also provide you with an understanding of the basic operational and maintenance concepts for wastewater collection systems and with an ability to analyze and solve problems when they occur. Operation and maintenance programs for wastewater collection systems will vary with the age of the system, the extent and effectiveness of previous programs, and local conditions. You will have to adapt the information and procedures in this manual to your particular situation.

Technology is advancing very rapidly in the field of the operation and maintenance of wastewater collection systems. To keep pace with scientific advances, the material in this program must be periodically revised and updated. This means that you, the wastewater collection system worker, must be aware of new advances and recognize the need for continuous personal training reaching beyond this program. Training opportunities exist in your daily work experience, from your associates, and from attending meetings, workshops, conferences and classes.

For many years the Water Pollution Control Federation, its member associations, state and local utility agencies, and colleges and universities have sensed a need for improvement in the dissemination of information on the operation and maintenance of wastewater collection systems. They have also felt a need for better training opportunities in this field. However, because of the lack of communication between the practical people doing the work in the field and the professional people in charge of publishing and training activites, the dissemination of information and training in the collection system field has been, until a few years ago, almost negligible compared to that in the wastewater treatment plant field.

Following completion of and the successful results from EPA's national field study training program, *Operation of Wastewater Treatment Plants*,[2] a similar effort appeared desirable for wastewater collection system workers. In cooperation with the California Water Pollution Control Association, the project directors prepared and submitted a proposal to the Environmental Protection Agency for financial support through the Foundation of California State University, Sacramento. CWPCA President Robert Bernicchi requested the Presidents of the Water Pollution Control Federation's member associations to urge EPA to support this national effort to develop a training manual for wastewater collection system workers. Response from the member associations was quick, the need was documented, and EPA approval received. Chapters were written, presented at small informal seminars, reviewed by consultants and reviewers from throughout the United States, field tested by potential and experienced collection system workers, reviewed by the Environmental Protection Agency, and revised after each step in accordance with the suggestions and experiences gained from these sources.

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[2] "Operation of Wastewater Treatment Plants," by Kenneth D. Kerri and Bill B. Dendy, California State University, Sacramento, 6000 Jay Street, Sacramento, California 95819. Price $25.00.

The California Water Pollution Control Association would like to acknowledge the cooperation and assistance in review that it received from the Personnel Advancement Committee and the Wastewater Collection Systems Committee of the Water Pollution Control Federation during the development of this publication.

The project directors are indebted to the authors of each chapter and the many potential and experienced collection system workers who field tested and reviewed the material. Mr. F. J. Ludzack, National Training Center, Office of Water Program Operations, Environmental Protection Agency, offered many technical improvements. Dr. Elie Namour, author of EPA's "Manpower Manuals for Wastewater Collection Systems," reviewed the manpower aspects of the manual. Our Program Manager, Mr. Robert Rose, Chief, State and Local Training Activities Section, EPA, served as a valuable source of information and guidance. A special note of thanks is due to our typists, Ms. Charlene Arora and Mrs. Elaine Saika, who somehow managed to cope with illegible handwriting and unmeetable deadlines with smiles and perfect manuscripts. Illustrations were drawn by Mr. Martin Garrity. Some sketches and line drawings were prepared by George Gardin and Sue Hashimoto.

KENNETH D. KERRI

JOHN BRADY

SPECIAL NOTICE

All job titles or descriptions of duties of wastewater collection system workers in this manual are identified with "Standard Occupational Titles." We have tried to describe job titles and duties with words that reflect or describe actual tasks performed. These words were used to help you understand the jobs and duties of each person on a crew.

Describing our job titles according to "Standard Occupational Titles" will help you and your employer realize the knowledge, skills and traits you need to do your job. Use of "Standard Occupational Titles" helps workers prepare for and accept jobs throughout the United States because all of us are talking about the same job. If you work for a small agency, you may be expected to be a "jack-of-all-trades" and do many different types of jobs, regardless of your job title. Workers for a large agency may become a specialist in one or two tasks, but often are expected to be knowledgeable about and skilled at several jobs. The U.S. Employment Service prepared the "Standard Occupational Titles" and emphasizes that these titles "CANNOT BE CONSIDERED STANDARDS FOR SETTING WAGES OR HOURS, OR SETTLING JURISDICTIONAL MATTERS."

INSTRUCTIONS TO PARTICIPANTS

Procedures for reading the lessons and answering the questions are contained in this section.

To advance steadily through this program, you should establish a regular study schedule. For example, many workers in the past have set aside two hours during two evenings a week for study.

The study material is contained in eleven chapters and two appendices. Some are longer and more difficult than others. For this reason, many of the chapters are divided into two or more lessons. The time required to complete a lesson will depend on your background, experience, and study habits. Some people may require an hour to complete a lesson, and some might require three hours, but that is perfectly all right. The important thing is that you understand the material in the lesson! Each lesson is arranged for you to read a short section, write the answers to the questions at the end of the section, compare your answers against suggested answers; and then you decide if you understand the material sufficiently to continue or whether you should reread the section. You will find that this procedure is slower than reading a typical textbook, but you will know and be able to use the information much better when you have finished the lesson.

Some discussion and review questions are provided following each lesson in some of the chapters. These questions review the important points you have covered in the lesson. At the end of each chapter, you will find an "objective test" containing true or false, multiple choice, fill in the blank, or match the answers types of questions. The purposes of this exam are to review the chapter and to give you experience in taking different types of exams.

Mail to the program director only your answers to objective tests on the answer sheets.

In this program you are your own teacher. You could merely look up the suggested answers at the end of each chapter or copy the answers from someone else, but you would not have given yourself a chance to understand the material. Consequently, you would not be able to apply the material to the operation and maintenance of your collection system nor recall it during an examination for certification or a civil service position.

You will get out of this program what you put into it.

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SUMMARY OF PROCEDURE

A. WORKER

1. Reads what he is expected to learn in chapter (objectives of each chapter).
2. Reads sections in lesson.
3. Writes answers to questions at end of sections in his notebook. You should write the answers to the questions just like you would if these were questions on a test.
4. Compares answers with suggested answers.
5. Decides whether to reread section or to continue with the next section.
6. Writes answers to discussion and review questions at the end of lessons in the notebook.
7. Marks answers to objective test on answer sheet.
8. Mails answer sheet for objective test to program director.

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B. PROGRAM DIRECTOR

1. Mails manual in advance.

2. Corrects tests, answers any questions, and returns results to collection system workers.

C. ORDER OF WORKING LESSONS

To complete this program you will have to work all of the chapters. You may proceed in numerical order, or you may wish to work some lessons sooner. If you are working on a specific job such as pipeline cleaning, you may wish to read Chapter 5 after Chapter 2.

Safety is a very important chapter. Everyone working in and around wastewater collection systems must always be safety conscious. You must take extreme care with your personal hygiene to prevent the spread of disease to yourself and your family. Collection system workers may have to work in and near excavations, embankments (fills), washouts, below grade structures, traffic and other dangerous situations and equipment that can cause a serious disabling injury if the worker is not aware of the potential danger and does not exercise adequate precautions. Confined spaces such as manholes and wet wells may have harmful atmospheres such as toxic gases, explosive mixtures, or oxygen deficiencies. For these reasons, you may decide to work on Chapter 9, Safety for the Collection System Worker, before completing the other chapters.

D. COMPLETION

Following successful completion of this program, a Certificate of Completion will be sent to you. If you wish, the Certificate can be sent to your supervisor, the mayor of your town, or any other official you think appropriate. Some workers have been presented their Certificate at a City Council meeting, got their picture in the newspaper and received a pay raise. When you successfully complete the course, the Project Director will ask you how you would like your name to appear on your Certificate and if you would like the Certificate sent directly to you, or to your supervisor or other municipal official.

COURSE OUTLINE

Chapter	Topic
1	THE WASTEWATER COLLECTION SYSTEM WORKER, by Walt Driggs
2	WHY COLLECTION SYSTEM OPERATION AND MAINTENANCE? by Walt Driggs
3	WASTEWATER COLLECTION SYSTEMS, by Steve Goodman
4	SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS, by George Freeland
5	PIPELINE CLEANING AND MAINTENANCE METHODS, by Dallas Hughes
6	UNDERGROUND REPAIR AND NEW CONSTRUCTION, by William Puchuff, Jim Hicks, Mel Arts and John Dolenga
7	LIFT STATIONS, by Manuel Munoz and John Brady
8	EQUIPMENT MAINTENANCE, by Lee Doty
9	SAFETY FOR THE COLLECTION SYSTEM WORKER, by Glenn David
10	ADMINISTRATION, by Neal Townley
11	ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE, by John Brady, John Cavoretto and George Gardin

Appendix	
G	COLLECTION SYSTEM WORDS, by George Freeland
M	APPLICATIONS OF ARITHMETIC TO COLLECTION SYSTEMS, by Kenneth Kerri

TECHNICAL CONSULTANTS

John Cavoretto
Ira Cotton
George Gardner
William Garber
James Kenmir
Warren Prentice

CHAPTER 1

THE WASTEWATER COLLECTION SYSTEM WORKER

by

Walt Driggs

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OBJECTIVES

CHAPTER 1. THE WASTEWATER COLLECTION SYSTEM WORKER

At the beginning of each chapter in this manual you will find a list of OBJECTIVES. The purpose of this list is to stress those topics in the chapter that are most important. Contained in the list will be items you need to know and skills you must develop to operate, to maintain, and to repair your wastewater collection system as efficiently and safely as possible.

After completion of Chapter 1 you should be able to do the following:

1. Explain the type of work done by collection system workers,
2. Describe where to look for jobs in this profession,
3. Know how to learn how to do the jobs performed by collection system workers.

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CHAPTER 1. THE WASTEWATER COLLECTION SYSTEM WORKER

Chapter 1 is prepared especially for new or potential wastewater collection system workers. If you are an experienced maintenance man or wastewater collection system worker, you may find some new viewpoints in this chapter.

1.1 LET'S START LEARNING

I know that there are some of you working in the wastewater collection profession who feel you are the forgotten person due to lack of available books to help you improve yourself. Admittedly many books have been written by and for engineers on wastewater collection systems, but very few have been written by and for collection system workers. There are also those of you who are just starting out in this field. We hope this manual will help all of you in your attempts to improve your knowledge of the operation and maintenance of wastewater collection systems. We, the authors, dedicate ourselves to opening the eyes of those responsible for the collection and conveying of wastewater to make them more aware of the need for adequate equipment and good operation and maintenance practices.

Some of you may be called sewer workers. Today workers in wastewater collection systems may be called maintenance men or TV system operators. Throughout this manual people working with wastewater collection systems are called collection system workers. By using words that better describe our jobs, we can improve our public image and upgrade our profession. The Environmental Protection Agency considers us to be in the business of operating and maintaining wastewater collection systems. The wastewater is usually collected and conveyed in sewer pipes. If you find words or terms you don't understand as you progress through this manual, try looking up their meaning in Appendix G, Collection System Words, at the end of this manual.

1.2 WHAT IS A WASTEWATER COLLECTION SYSTEM?

A wastewater collection system gathers the used water from our homes and businesses and conveys it to a wastewater treatment plant (Figure 1.1). This water may come from the kitchens or processes of businesses and industries. Sometimes ground water, surface water and storm water may be present too. The collection system includes the gravity sewers, force mains, manholes, pumping equipment and other facilities that collect and convey the water to a wastewater treatment plant. Collection systems designed solely for storm waters usually convey these waters to streams, rivers, lakes or the ocean. Details on the parts of wastewater collection systems are described in Chapter 3.

1.3 WHAT IS MEANT BY OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS?

Operation and maintenance (O & M) of wastewater collection systems is similar to the O & M program of any other utility. The facilities should be kept in good operating condition. We would not be satisfied if the water company that serves our homes did not deliver water every time we turn the handle of a faucet. The same goes for the gas company that supplies gas to heat our homes. We don't want excuses why the gas or water delivery system has failed. We expect to have all the gas and water we want when we need it. Recall how annoyed we become if our phone doesn't work? We wonder why the phone company can't keep the phone service working all the time.

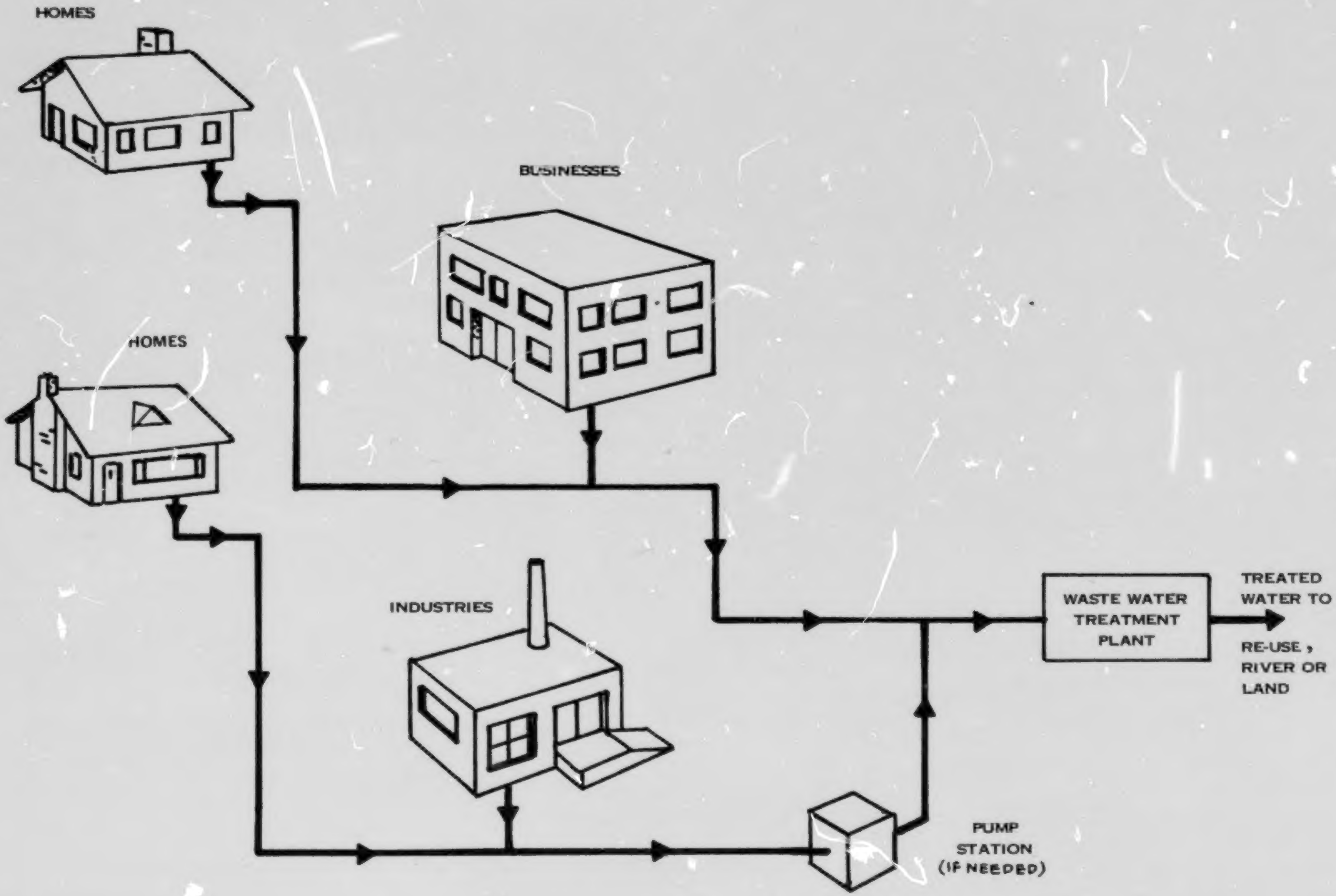

HOMES
BUSINESSES
HOMES
INDUSTRIES
WASTE WATER TREATMENT PLANT
TREATED WATER TO
RE-USE , RIVER OR LAND
PUMP STATION (IF NEEDED)

Fig. 1.1. Contributors to wastewater collection systems

What happens when wastewater collection systems fail? Here are some of the problems that can develop.

1. A drain in the kitchen, bathroom or basement fails to work, but the other drains in the house or building work properly. If this failure is noticed quickly, the particular basin served by the drain may contain the water or drainage until the faucet is shut off or the drain is unplugged. The householder may have a plunger, reamer or chemical cleaner and know how to use these methods to clear the stoppage. This is a local problem and can be quickly resolved. If the householder can't clear the stoppage, it's still a local problem. A plumber can clear the stoppage, but this costs money and the stoppage is not cleared immediately.

2. A stoppage develops in a household drainage system when an occupant has started a water using appliance or fixture. The occupant walks away to visit, use the phone, or enjoy the outdoors. While the occupant is gone, quite a mess can develop. Water continues to flow from the appliance or fixture unless it is on a timed cycle. The basin served by the stopped drain overflows and the floor becomes a drainage route. Rugs and carpet get pretty soggy. If a doorway or floor drain doesn't allow drainage, the repair and cleanup job becomes very extensive and expensive. However, this is still a local or occupant problem.

3. A stoppage in the floor drain system in the basement floor becomes very serious, especially if it isn't noticed quickly. All drainage or feeder lines to the floor drains contribute to the flooding. The water supply to the home or building must be shut off to limit damage until the stoppage is removed. If you have a friendly neighbor, you can still get the necessary household services until the situation is corrected by your efforts or the efforts of a plumber. If you fail to shut off the water supply soon enough, you may have a flooded basement. When this happens the pilot lights for your home or space heater and water heater become flooded. All electrical appliances contribute to an expensive and dangerous situation.

4. If a stoppage develops beyond the property line, it usually does not have to be cleared by the occupant or by a plumber. When flooding occurs from the lowest drains in a house or building, contact occupants of adjacent buildings with lower floor drains in an attempt to locate the area of the stoppage. Determine if these people are experiencing slow drainage or backflow. If they are, phone the sewer maintenance department and give them all of the available information you have on location, extent and nature of the problem.

   The sewer maintenance department will start corrective action as soon as possible. Current workload, available staffing and equipment, priorities related to their workload, extent of damage from stoppage and area affected will enter into the quickness of their response to each particular problem. First they have to locate the stoppage and determine what can be done about it. They may start temporary pumping or alternate routing of wastewater to relieve the drainage problem above the obstruction. If it is a simple stoppage, it may be promptly cleared. A major structural failure of a pipe may require some time to repair.

   Some agencies have a policy of encouraging the public to call them whenever a stoppage of any kind develops. The idea behind this policy is that if the stoppage is in the main line, the agency wants to clear it as soon as possible in order to minimize damage to homes and overflow from manholes.

Let's compare implications of service interruptions of common public services such as telephone, gas, water supply, electrical supply, and wastewater collection systems. We know each of these systems occasionally fails. Whenever any one of these services fails, a nuisance condition develops that tends to produce a highly emotional response depending upon the individual and the situiation.

A telephone failure means going to the nearest working telephone to report the problem. The telephone service people may find the cause of the problem in a central office or they may send repair personnel to your home. You may miss a few phone calls or be inconvenienced. Usually you can reach a nearby working phone.

The water supply may stop as a result of a line break in your home or beyond your property line. If the failure occurs on your property, you shut off the water supply at the meter or curb and call a plumber. If the failure occurs beyond your meter or curb, you call the water supply service agency. They will correct their problem as soon as possible, depending upon the nature and extent of the service interruption and what is required to restore service. In the meantime you may have to depend on a friendly neighbor for an alternate water supply service. There may be water damage, but hopefully a serious washout will not be caused by a major line breakage.

Natural gas service interruption may be the result of a stoppage or leaks in the delivery system. Gas is odorized to provide a warning if a leak occurs. Proceed with caution at any time there is any suspicion of gas leakage. Explosive limits for natural gas in air are from about 1 to 33 percent gas. All this mixture needs is a spark to cause a fire or an explosion. A defective heater, heater controls, flame blowout, or leaking pipes all can provide pockets of gas. When a gas leak is suspected or discovered, ventilate the area, guard against a spark (absolutely no smoking), and call the municipal gas service immediately. Explosion and/or fire are serious hazards. Even a small one causes a messy cleanup job. A major explosion or fire may result in an injury or loss of life, and extensive property damage or destruction. Preventive maintenance is the only safe and sane course of action.

Electric power interruption affects lighting, power, automatic controllers, alarms and safety devices. The householder must use candles (if there are no gas leaks), flashlights, manual controls and do-it-yourself ingenuity. Refrigerators, freezers and air conditioners don't work. For a short time the refrigerator and freezer will protect their contents if they are kept closed. The electric service agency will take action as soon as they are notified, but they are not magicians. They must have time to locate the problem, gather staff and equipment, and repair the problem. The failure may be due to a fuse or thermal breaker in the house caused by defective wiring or appliances. A major brownout or blackout in the area could be caused by central or substation damage or failure. Line damage can be repaired relatively rapidly if only one or two lines are involved. A major ice or wind storm can affect many lines and a long time will be required to restore service even with imported maintenance crews and equipment.

The interruption of wastewater collection service, like drinking water service, generally promotes a more emotional response then failures of other utilities. Possibly this is because the customers have been underfunding collection system maintenance and repairs for years and want the municipality to make it disappear on a "free ride" basis. Collection system maintenance and repair is an expensive operation and is usually a low priority item on the municipal budget when compared with streets, public buildings, parks, schools, police and fire protection that can be seen everyday by the public.

What happens?

When a stoppage develops or flow in excess of the sewer capacity cannot escape, the wastewater starts to back up in the sewers and flows out manholes into the streets or through the lowest elevation basement drains or house drains connected to the sewer. Households at higher elevations may experience no problems because their drains are above the elevation of the stoppage and the backed-up wastewater. Actually these homes are contributing to the basement backflow in the lower elevation drains. The lowest households upstream from the stoppage receive the collected backflow. A stinking mess develops that creates a health, odor, and filth problem.

The low section households can shut off their water supply, but the sewer backflow continues from the higher elevation connections. Flooded basements tend to cause cross connections between the water supply and the sewer by allowing wastewater to reach water supply faucets, thus possibly contaminating the public water supply. When flooding of basements occurs, electric and gas utilities must be shut off immediately. Telephone lines become jammed because more than 10 to 15 percent of the users in the area are trying to complain and get the situation corrected. Any utility interruption is a serious inconvenience and a potential hazard. A collection system failure creates a health and sanitation hazard and possibly interrupts all of the utilities serving the affected area. Residents of affected buildings usually must find alternate shelter and services somewhere else until service can be restored to the affected area and the individual households can be cleaned, repaired or replaced.

The wastewater collection system worker is a key individual with a major affect upon the health and general well-being of the community. Recognition of this status is being improved, but it has a long way to go. Better trained and motivated individuals working for collection system agencies are essential to present a better case for improved priorities and public recognition.

1.4 WHAT DOES A COLLECTION SYSTEM WORKER DO?

Simply described, collection system workers keep the system working. They inspect the system to keep the wastewater flowing today and in the future. Physically they have manual and power operated equipment to help them with the job. Some of the jobs they do include inspecting and/or installing new service connections, using closed circuit television to inspect sewers where there is no other way to observe the system, cleaning sewers, removing stoppages in sewers, maintaining equipment, and repairing lines, equipment and facilities. From an overall viewpoint, collection system workers are responsible for the collection of wastewater and the conveying of the wastewater to a treatment plant. The better the job collection system workers do, the more effective a treatment plant can do its intended job.

Using TV to inspect sewer pipes?

1.5 WHO HIRES COLLECTION SYSTEM WORKERS?

Workers paychecks usually come from a city, sanitation district, or private utility company. They also may be employed by a sewer cleaning contractor. Either way, they are playing an important part in maintaining the good health of the community. It is these vitally affected people for whom the collection system workers are really working.

QUESTIONS

Place an X by the correct answer or answers (more than one answer may be correct). After you have answered all the questions, compare your answers with those given at the end of this chapter on page 1-17. Reread any sections you do not understand and then proceed to the next section. You are your own teacher in this training program, and you should decide when you understand the material and are ready to continue with new material.

EXAMPLE

This is a training manual on:

_____ 1. Arithmetic

_____ 2. Engineering

__X__ 3. Wastewater Collection Systems

_____ 4. Truck Driving

1.2A The main purpose of a wastewater collection system is to gather:

__✓__ 1. Spent or used water from our homes and businesses.

_____ 2. Irrigation water from fields.

_____ 3. Waste material from junk yards.

_____ 4. Drinking water from lakes.

1.3A Why must wastewater collection systems be properly operated and maintained?

✓ 1. So wastewater won't flood our homes.

✓ 2. To keep your employer from being sued for damages caused by wastewater.

_____ 3. So collection system workers will have extra time to repair streets.

✓ 4. To keep the collection system's office phones from being busy all of the time.

1.4A What does a collection system worker do?

✓ 1. Keeps the collection system working.

✓ 2. Repairs underground pipes and manholes.

✓ 3. Removes stoppages.

✓ 4. Cleans sewers.

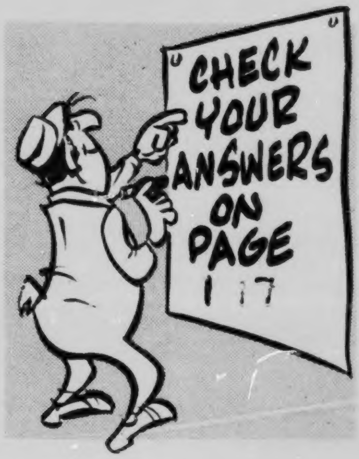
✓ 5. Maintains collection system equipment.

1.5A Who hires collection system workers?

✓ 1. City.

✓ 2. Sanitation District.

✓ 3. Pipeline Cleaning Contractor.



1.6 WHERE DO COLLECTION SYSTEM PEOPLE WORK?

1.61 On the job

You may be surprised, but if you are working for an agency or contractor that is up to date, you will spend very little time in a sewer or manhole. Modern technology has developed equipment and procedures to reduce unpleasant tasks as much as possible. Most of the work is done from "topside". But if you must work underground, (below the ground surface) learn to do it safely.

Throughout this manual, you will learn how to protect yourself and your fellow workers whether you are working underground or topside. If you must work underground or in confined spaces in the collection system, be sure to follow your supervisor's instructions. If you or your supervisor have questions or doubts, your supervisor should consult with an experienced associate or your agency or local rules and regulations provided for your safety. If you work for a small contractor or agency that does not have a safety officer, consult with your state or federal OSHA (Occupational Safety and Health Act) safety people BEFORE you take a chance.

Your employer wants you to be a hit, but not a smash (WORK SAFE).

1.62 In the City and In the Country

Jobs are available for wastewater collection system workers wherever people live and discharge the wastewater from their homes into a common collection system. From the mountains to the sea and everywhere in between are found wastewater collection systems. You have the opportunity to work for either a small or large agency. The choice is yours if you can convince an employer that you have the knowledge and skills necessary to do the job.

1.7 WHAT PAY CAN A COLLECTION SYSTEM WORKER EXPECT?

In dollars? Prestige? Job satisfaction? Community service? In opportunities for advancement? By whatever scale you use, returns are what you make them. If you choose a large municipality, the pay is good and advancement prospects are tops. Choose a small town or contractor and the pay may not be as good, but job satisfaction, freedom from time-clock hours, community service, and prestige may well add up to outstanding personal achievement. If you have the ability and the opportunity, you can make this field your career and advance to the top. Many of these positions are or will be represented by a union that will try to obtain higher pay and other benefits for you. Starting salaries for new workers currently range from $500 to $800 per month and depend on many factors. Total reward depends on you and how YOU APPLY YOURSELF.

1.8 WHAT DOES IT TAKE TO BE A COLLECTION SYSTEM WORKER?

DESIRE. First you must choose to enter this profession. You can do it with a grammar school, a high school, or a college degree. While some jobs will always exist for manual labor, the real and expanding need is for qualified workers. You must be willing to study and take an active role in upgrading your capabilities. The high velocity cleaners and closed circuit television inspection units are examples of the costly and sophisticated equipment used by our profession today. Employers will not risk their investment by allowing unqualified workers to operate this complex equipment.

What will be your job title? This will depend on how your employer classifies job titles. Today a sewage treatment plant operator may be called a water quality control plant operator, a janitor may be called a custodian, and a garbage man a refuse collector. All of these new job titles were developed to make the job more acceptable to the general public. Whether you are called a wastewater collection system worker or a sewer maintenance worker, you should be proud of where you work and of your job. You can become a better qualified professional worker; ready for advancement by increasing your knowledge today.

Obviously this manual cannot train you to be an expert equipment operator, familiar with each handle on all machines, but it will tell you how to select equipment, what it can and can't do, and how to keep records of your activities. All of these factors are essential to proper operation and maintenance of your collection system.

This training manual can be your start towards a future filled with a different challenge each day and job satisfaction that most people never achieve and enjoy.

1.9 YOUR PERSONAL TRAINING COURSE

Beginning on this page you are starting on a training course which has been carefully prepared to allow you to improve your knowledge and ability to operate and to maintain wastewater collection systems.

You will be able to proceed at your own pace; you will have an opportunity to learn a little or a lot about each topic. The manual has been prepared this way to fit the various needs of collection system workers, depending on the size and type of collection system for which you are reponsible. To study for certification and civil service exams you may have to cover most of the material in this manual. You will never know everything about wastewater collection systems and the equipment and procedures available for operation and maintenance, but you can begin to answer some very important questions about how, why, and when certain things happen in collection systems. You can also learn how to manage your collection system to minimize stoppages, odors, failures, and costs to taxpayers in the long run.

This training course is not the only one available to help you improve your abilities. Some state water pollution control associations, community colleges and universities offer training courses on both a short - and long - term basis. Many state, local and private agencies have conducted training programs and informative seminars.

Libraries can be an excellent source of useful journals and books. Many very helpful publications have been developed and distributed by the:

WATER POLLUTION CONTROL FEDERATION
2626 Pennsylvania Avenue, N.W.
Washington, D. C. 20037

Publications listed below will provide interesting reading and additional information. Prices are 1976 list prices. All prices listed in this manual are the most recent prices available when the manual is printed.

	WPCF Members	Others
1. Manual of Practice (MOP) 1. Safety in Wastewater Works.	$1.00	$2.00
2. MOP 3. Regulation of Sewer Use.	1.00	2.00
3. MOP 7. Sewer Maintenance.	1.50	3.00
4. MOP 9. Design and Construction of Storm and Sanitary Sewers.	5.00	10.00

Note that Water Pollution Control Federation members can buy publications at half price. You can join the WPCF by writing to the address cited on the previous page. The WPCF can help you contact your own state and local water pollution control association. These professional organizations can offer you many helpful training opportunities and educational materials when you join and actively participate with your associates in the field.

QUESTIONS

Write your answers in a notebook. When you write your answers, you are helping yourself learn and remember the answer. Compare your answers with the suggested answers on page 1-17.

1.6A Where do collection system people work on the job?

1.6B Who can help you determine safe procedures for working underground?

1.8A What does it take to be a collection system worker?

1.9A Where else besides this manual could you look for information and help to learn more about wastewater collection systems?

SUGGESTED ANSWERS

CHAPTER 1. THE WASTEWATER COLLECTION SYSTEM WORKER

You are not expected to have the exact answer suggested for questions requiring written answers, but you should have the correct idea.

1.2A
1. Spent or used water from our homes and businesses.

1.3A
1. So wastewater won't flood our homes.
2. To keep your employer from being sued for damages caused by wastewater.

1.4A
1. Keeps the collection system working.
2. Repairs underground pipes and manholes.
3. Removes stoppages.
4. Cleans sewers.
5. Maintains collection system equipment.

1.5A
1. City.
2. Sanitation District.
3. Pipeline Cleaning Contractor.

1.6A On the job collection system people work both topside and underground in manholes and sewers. Modern technology is continually developing equipment and procedures to make our job more pleasant and easier, as well as help us do a better job.

1.6B Your supervisor, an experienced associate, or your agency or local safety officer or a state or federal safety officer can help you determine safe procedures for working underground. This manual also outlines safe procedures.

1.8A DESIRE is the main requirement to be a collection system worker. Also you have to be willing to study and upgrade your capabilities.

1.9A To learn more information and gain help regarding wastewater collection systems, contact the Water Pollution Control Federation, state and local associations, state pollution control training agencies, colleges, and universities. Libraries can be an excellent source of useful journals and books.

HOW TO WORK THE OBJECTIVE TESTS

At the end of each chapter is an objective test.

1. Use the special answer sheets that will be provided for each chapter that have your name, address, social security number and the chapter number.
2. Mark your answers on the answer sheet using a Number 2 lead pencil. Mark only the space between the lines. Neatly erase any errors.
3. Please provide us with any comments that could help us improve the chapter. We would appreciate your comments and suggestions regarding:
   a. Clarity and content of chapter.
   b. Clarity and content of questions.
   c. Any words you did not understand.

Please write your comments on extra sheets other than the answer sheet. Mail your answer sheet and comments to:

Ken Kerri
California State University, Sacramento
6000 Jay Street
Sacramento, California 95819

PAGE 1-19 "Optical Scanning Form" removed prior to being shipped to EDRS for filming due to copyright restrictions.

OBJECTIVE TEST

CHAPTER 1. THE WASTEWATER COLLECTION SYSTEM WORKER

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one answer to each question.

1. Why is the word wastewater used instead of sewage?

    1. Because it is longer.
    2. To improve our public image.
    3. To upgrade our profession.
    4. To confuse the public.
    5. Because people are funny.

2. Wastewater comes from

    1. Homes
    2. Trees
    3. Businesses
    4. Manholes
    5. Springs

3. Wastewater collection systems are intended to gather and convey

    1. Refuse from streets.
    2. Used water from our homes.
    3. Water from trees.
    4. Industrial wastewater.
    5. Water wasted by farmers.

4. Operation and maintenance of wastewater collection systems is similar to the O & M program of any other utility?

    1. True
    2. False

5. What happens when wastewater collection systems fail?

    1. The worker must correct the situation.
    2. The worker fails to get paid.
    3. The public fails to get mad.
    4. Wastewater can flow into homes.
    5. Wastewater gets treated.

GO ON TO NEXT PAGE

6. Wastewater collection system workers

   1. Drive fast cars on the job.
   2. Use closed circuit television to inspect sewers.
   3. Clean sewers.
   4. Operate refuse collection systems.
   5. Maintain collection system equipment.

7. What does it take to be collection system worker?

   1. Desire.
   2. Friends in high places.
   3. A college degree.
   4. Money.
   5. Tall and thin.

8. Where can collection system workers look for more information and training courses to improve themselves?

   1. Water Pollution Control Federation.
   2. Libraries.
   3. State and Local Water Pollution Control Associatios.
   4. Federal, State, and Local Water Pollution Control Agencies.
   5. Colleges and Universities.

CHAPTER 2

WHY COLLECTION SYSTEM OPERATION AND MAINTENANCE?

by

Walt Driggs

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OBJECTIVES

CHAPTER 2. WHY COLLECTION SYSTEM OPERATION AND MAINTENANCE?

After completion of Chapter 2 you should be able to do the following:

1. Describe the problems of operating and maintaining a wastewater collection system.
2. Justify the need to operate and maintain the system.
3. Tell what collection systems are expected to achieve.

CHAPTER 2. WHY COLLECTION SYSTEM OPERATION AND MAINTENANCE?

2.1 STATEMENT OF PROBLEMS

Eric Hoffer has said, "One's capacity to endure is directly related to the quality of his maintenance." Certainly this is true of wastewater collection systems. Preventive maintenance is talked about, but seldom practiced. Decades of neglect, or grossly inadequate maintenance, are two reasons why wastewater collection systems are now a thirty billion dollar price tag facing our Nation at a time when the economy can ill afford the cost.[1]

$30,000,000,000.00

How did this come about?

1. Wastewater collection systems were engineered as gravity flow[2] sewers with inadequate flow capacities for the area served or for the unexpected population growth.

2. Collection systems were not installed as designed. Problems are caused by faulty construction, poor inspection and low-bid short cuts.

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[1] "1974 Needs" Survey, Cost Estimates for Construction of Publicly-Owned Wastewater Treatment Facilities," U.S. Environmental Protection Agency, Office of Water Programs, Municipal Construction Division, Washington, D.C., 1975.

[2] Gravity flow. Water or wastewater flowing from a higher elevation to a lower elevation due to the force of gravity. The water does not flow due to energy provided by a pump. Wherever possible, wastewater collection systems are designed to use the force of gravity to convey waste liquids and solids.

3. Little thought was given to the fact that sewers, although made of permanent material, could be considered only as permanent as the joint. Earth movement, vibration from traffic, settling of structures and construction disturbance (all occur from time to time) require a flexible pipe material or joint that can maintain tightness, yet joints were made rigid.

4. Not enough scientific knowledge existed or was available to designers about potential damage to pipe joints by plant roots. Although root intrusion into sewers was age-old, it was assumed that if the joint was watertight, it would be roottight. People did not realize that roots would be attracted by moisture and nutrient vapor unless the joints were vaportight (which means airtight). Roots can enter a pipe joint or walls microscopically (through extremely small holes or cracks); thus, open or leaking joints are not necessary for root intrusion in collection systems.

   Collection system environments are ideal for root growth. In this environment, roots enter, expand and open joints and cracks. Root growth is a principal cause of pipe damage that allows infiltration[3]/inflow[4] and exfiltration.[5] This creates a major concern for health and pollution control authorities because of wastewater treatment plant overload and ground water pollution.

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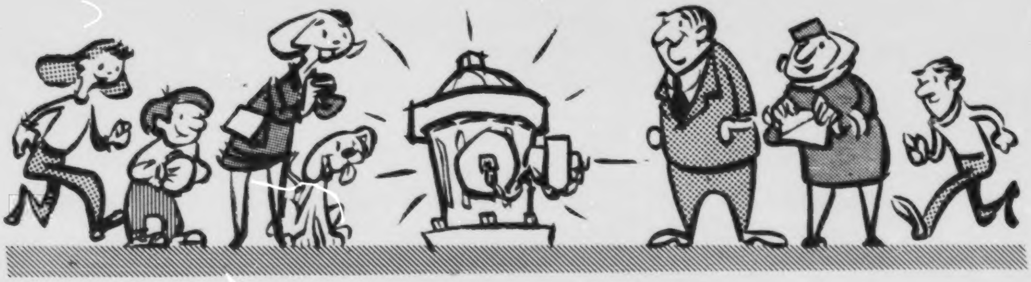
[3] INFILTRATION (pronounced IN-fill-TRAY-shun). The water entering a sewer system and service connections from the ground, through such means as, but not limited to, defective pipes, pipe joints, connections or manhole walls.

[4] INFLOW. The water discharged into a sewer system and service connections from such sources as, but not limited to, roof leaders, cellar, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, around manhole covers or through holes in the covers, cross connections from storm and combined sewer systems, catch basins, storm waters, surface runoff, street wash waters or drainage.

[5] EXFILTRATION (EX-fill-TRAY-shun). Liquid wastes and liquid carried wastes which unintentionally leak out of a sewer pipe system and into the environment.

5. The out of sight, out of mind nature of the wastewater collection system. Local taxpayers have invested more money in underground sewers than in all the structures above ground owned by their local government. Why has this great taxpayer investment been so grossly neglected? Because it is out of sight, and so, out of mind. Some cities spend more money repairing and replacing sidewalk sections because of earth movement and tree-root damage, than on preventive maintenance of wastewater collection systems.

6. Many collection systems are maintained by a department charged with street, sidewalk, storm drain, and sometimes water utility maintenance. Now, I leave it to you to guess where the money is spent. Money is usually spent where the taxpayer can see it, especially when the budget is inadequate for the total need. How often do you see a sign, "Your tax dollar is at work cleaning and repairing your sewer?"



7. The ditches in which sewers are installed have the bottoms sloping downhill to produce gravity flow. Gravel and sand placed in the ditch for pipe bedding and cover create ideal conditions to move water for great distances down the trench. Water that enters this backfilled ditch is not easily percolated (seep) out of the ditch because the usual silt and clay soils have been compacted both on the ditch bottom and sidewalls by the heavy excavation equipment.

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Many of these ditches start at the toe (bottom) of foothill slopes where the natural soil conditions produce springs or lateral water flow into the ditch. This water can cause flow down the ditch and create serious problems along a downstream sewer where no one would expect water in the ditch. Problems that can develop include ground water infiltration into the sewer, possible flotation of the sewer, or structural failure of the sewer or joint.

8. The Administrator of the Environmental Protection Agency cannot authorize grants for the construction of wastewater treatment plants if the wastewater collection system discharging into a plant is subject to excessive infiltration.[6] Consequently municipalities must reduce infiltration to the extent that is cost effective and properly maintain the wastewater collection system to qualify for federal construction grants. Reducing infiltration/inflow is good practice because it allows the collection system to handle greater quantities of wastewater.

This discussion has explained why many wastewater collection systems now present such a mammoth problem to the taxpayer and governmental agencies. Fortunately there exist today properly designed, constructed, operated and maintained collection systems that can serve as examples of how the job should be done. Leakage should not be a problem in properly constructed and maintained sewers.

Operation and maintenance of wastewater collection systems on a trouble or emergency basis has been the usual procedure and policy in many communities and districts. Planned operation and preventive maintenance of the collection system has been delayed or omitted, in spite of desires by collection system workers. Municipal officials tended to neglect collection systems as long as complaints were not excessive. To please constituents, officials often demanded street and sidewalk repair be done by collection system crews, but seldom have they ever demanded preventive work on collection systems.

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[6] Public Law 92-500, Section 201. "Federal Water Pollution Control Act Amendments of 1972". 92nd Congress, S. 2770, Washington, D.C., October 18, 1972.

2.2 WHY HAVE COLLECTION SYSTEMS?

First we should consider why we have wastewater collection systems and then I think we will understand why we should take care of them. Collection systems were built to remove diseases that man comes in contact with when he lives surrounded by other people and their wastes. Roman and other early civilizations built drains and aqueducts to carry away their wastes. Wherever large population centers developed, a means of waste handling and removal was needed. In 1888, Dr. McVail reviewed the Methods and Objectives of Preventive Medicine. Three basic lines of defense were outlined as constituting the preventive measures. They were (1) sanitation (cleanliness), (2) inoculation (vaccination for protection against diseases), and (3) isolation (keeping sick people away from healthy people). Sanitation was considered the most important of the three. Also emphasized was the need for a good environment suitable for humans. If you wish more information, I suggest you read Waring's book on Sewerage and Land Drainage.[7] This was written in 1889, but many of the reasons for collection systems are true today!

SANITATION
INOCULATION
ISOLATION

---

[7] Waring, George Edwin, Sewerage and Land Drainage, D. Van Nostrand, New York, New York, 1889.

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2.3 COMPARISONS OF COLLECTION SYSTEMS

You will find city and county officials that will know the cost of each building and their total building budget. Bridges and parks are obvious and everyone can see neglect, but you will find few city and county officials who know for sure how many feet of sewers they have and the number of manholes in their system. Few cities or agencies have correct maps of their wastewater collection system or of the connections to the system. Officials become aware of sewers mainly when the service is inadequate, a stoppage occurs, the system fails, or odors are produced.

We know how many pumping plants are in the collection system, where the wastewater treatment plants we have are located, and the number of people we think it takes to operate and maintain them. Numbers of operators will vary from city to city, but you will find some agreement. Unfortunately officials often forget or neglect adequate inspection during construction, and fail to budget adequately for personnel and equipment requirements for the proper operation and maintenance of collection systems. The following sections contain comparisons of collection systems with highways, traffic signals and railroad crossings.

2.31 Highway and Street Comparison

Drive down a road. If it is too rough or bumpy you can call the highway department and complain. You and every other driver and passenger who have passed over that section of road know how bad it is. You become inspectors for the highway department. The highway patrol and local police will call in any unsafe section they see. Who notices a sewer if it isn't overflowing or stinking?

2.32 Traffic Signal Comparison

When the red light stays on a few seconds longer, you start to stew, but let it fail altogether and quite often you will spend your dime to call and report its failure. What is going on underground? Who is looking out for the collection system?

2.33 Railroad Crossing Comparison

What happens when the tracks are too rough and every low slung car hits bottom? Motorists call in and complain. The same thing happens when you have a manhole that is in the roadway and causes a bump, or the manhole cover rattles and keeps someone awake. They're interested in your collection system for the first time. Not quite so; just in the manhole that caused the bump or rattle.

You will find that the underground collection system won't draw much attention from anyone until the flow starts coming out of a manhole or some other low overflow point, such as a basement drain or shower drain in a home.

I think by now you are getting the point. One reason a staff is needed to operate and maintain a collection system is that you don't have all of the outside help to let you know when there is a problem. Most people tend to neglect devices and equipment until there is a serious squeak, rattle, or bump that makes the problem obvious and usually serious.

QUESTIONS

2.1A List five problems or reasons why many wastewater collection systems are in need of repair or replacement.

2.2A What is the purpose of wastewater collection systems?

2.3A Why aren't people more concerned about collection systems?

2.4 WHY OPERATION AND MAINTENANCE OF YOUR WASTEWATER COLLECTION SYSTEM?

2.41 What Is Operation and Maintenance?

Let's talk about something all of us understand - our car. You have to drive or operate your car to make it take you someplace. If you drive your car improperly or recklessly, you could have an accident and seriously injure yourself and damage your car. Also you have to consider such things as oil, water, grease, tires, and washing. This is the maintenance of your auto. Don't add or change oil and soon you will be walking. After this happens, anything you do could be a repair that was caused by your lack of maintenance. So operation is driving your car and maintenance is keeping it in good running order so that you can depend upon it when you need it.

Operation and maintenance of your wastewater collection system is not letting wastewater overflow into the street or into someone's home. After it has overflowed you must take emergency action because your operation and maintenance program did not prevent the stoppage.

Don't think the agency you work for is a failure if it has main line stoppages. These will occur in even a well operated and maintained system. You will wonder how the material causing the stoppage got into the line. I have found everything from bikes, tree limbs, blocks of concrete and even V. W. fenders in our sewers and manholes.

2.42 How to Tell When You Need To Do A Better Job

If the stoppage is roots, for example, in the same place each time and your records show it has happened ten times, you should have corrected this problem long ago.

Let's go back to your car that had no oil and caused you to walk and pay a big repair bill. No way would you let this happen ten times. You would soon find the cause for no oil and stop it from occurring again.

We need to have the same type of concern when a sewer stoppage occurs, the collection system produces obnoxious odors, or a lift station failure occurs.

2.5 THE COST OF YOUR WASTEWATER COLLECTION SYSTEM

When collection systems are installed, they sometimes cost significantly more than the cost of the wastewater treatment plant. If, for some reason, the collection system fails in, let's say, twenty years, the cost per foot for replacement could be as much as ten times its original cost. In some locations the replacement is practically impossible and extremely expensive because of the crowding of other utilities, and the fact that everything is going underground now makes this even more of a problem.

Good collection system inspection, operation and maintenance are by far the best ways to protect a large investment that the taxpayers have placed in your hands. An effective inspection program will alert you to small problems that should be corrected before they become big problems.

2.6 THE WASTEWATER COLLECTION SYSTEM DOCTOR

This manual will cover many ways to help you properly operate and diagnose the ills of wastewater collection systems. Even more important, it will teach you the cure for these ills.

Picture yourself now as a doctor of wastewater collection systems and seeking cures for the ills a collection system could acquire. The manual will equip you with many different ways to solve the same or similar problems.

As you become more acquainted with these methods and know how to evaluate each one, you will become a better employee and your feeling of job accomplishment will grow.

You are not always going to diagnose the problem correctly the first time, and may work on a symptom and not the cause of the problem. One way to avoid this is to review your information carefully for gaps and the method you have selected to correct the problem. Keep good records to help you next time. If you don't know about mistakes, you can't learn from them. Experience is trying and learning what works and doesn't work, and then avoiding use of the "didn't work" procedures again for these conditions. Try to learn from the experience of others in your field.

EXAMPLE

If possible and appropriate, TV the section in question. See, before you attempt to diagnose the problem. Go back and re-TV after corrective action to see if your selection of a corrective measure was effective. If you don't have a TV unit, maintain careful and accurate records of a problem section. Attempt to evaluate corrective action with other methods such as visual inspection mirrors and cleaning devices that can provide data regarding the condition of the section and the effectiveness of the action taken.

2.7 SUMMARY

In this chapter you have learned why it is necessary to operate and maintain wastewater collection systems. We have discussed some of the problems and how or why they occur. This is intended to introduce you to these topics. You will find more detail in later chapters.

You are now ready to go on to Chapter 3 which describes collection systems and deals with design and construction. Many problems actually originate when the collection system is first designed and built. Chapter 2 has told you why collection systems need to be properly operated and maintained. Chapter 3 actually begins the discussions on how to do it.

QUESTIONS

2.4A What is wastewater collection system operation and maintenance?

2.5A How can the taxpayer's investment in your wastewater collection system be protected?

2.6A What should you do after you have selected a method of solving a collection system problem and you think you have corrected the problem?

SUGGESTED ANSWERS

CHAPTER 2. WHY COLLECTION SYSTEM OPERATION AND MAINTENANCE?

2.1A Many wastewater collection systems are in need of repair or replacement because of

1. Inadequate capacities.
2. Improper construction, inspection and/or low-bid short cuts.
3. Joints that cannot flex and maintain tightness.
4. Insufficient concern for potential damage to pipe joints by plant roots.
5. Lack of preventive maintenance.
6. Priorities among other jobs a collection system maintenance department may have to do such as maintain streets, sidewalks, and the drinking water system.
7. Characteristic of ditches that allows surface or ground water to flow down ditch.
8. Corrosion of materials due to conditions found in collection systems.

2.2A The purpose of wastewater collection systems is to carry our wastewater away from our homes and industries to the wastewater treatment plant.

2.3A People aren't very concerned about collection systems because they are out of sight and out of mind.

2.4A Operation and maintenance of your wastewater collection system is not letting it overflow into the street or into someone's home. This means keeping the system in such a condition that stoppages rarely occur and when they do, they are quickly relieved.

2.5A Good collection system operation and maintenance is the only protection of the large investment the taxpayers have in the system.

2.6A After a problem has been corrected, the effectiveness of the corrective action should be evaluated and good records should be kept for future reference.

OBJECTIVE TEST

CHAPTER 2. WHY COLLECTION SYSTEM OPERATION AND MAINTENANCE?

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one answer to each question.

1. Many wastewater collection systems need repair or replacement because

    1. Low-bid construction led to short cuts in installation which poor inspection did not catch.
    2. Past maintenance of the collection system was either delayed or omitted.
    3. The pipe sizes were too big.
    4. Not enough roots were allowed to get into the pipes and remove the water.
    5. Pipe joints were rigid.

2. Roots can enter collection systems through pipe

    1. Cracks
    2. Joints
    3. Manhole walls not properly sealed
    4. Inverts
    5. Internal Diameters

3. Some cities spend more money repairing and replacing sidewalk sections because of earth movement and tree-root damage than on preventive maintenance of wastewater collection systems.

    1. True
    2. False

4. Ditches in which sewers are installed

    1. Have the bottoms sloping downhill.
    2. Can be used for latrines.
    3. Can use gravel for pipe bedding.
    4. May create an ideal condition to move water for great distances down the trench.
    5. May be used for drinking water pipes too.

GO ON TO NEXT PAGE

5. Wastewater collection systems are built to

   1. Keep engineers and contractors busy.
   2. Carry away potential disease producing material from our homes.
   3. Convey wastewater away from our homes.
   4. Connect pipes to manholes.
   5. Try and get money from the government.

6. Underground wastewater collection systems don't draw much attention from anyone because

   1. The price tag to repair collection systems is not high enough.
   2. The price is too high.
   3. They don't inconvenience anyone, except when they flood your home.
   4. They are out of sight and out of mind.
   5. The sewers are full of infiltration water.

7. Operation and maintenance of wastewater collection systems is

   1. Not letting wastewater overflow into the street.
   2. Not driving the truck over manholes.
   3. Keeping an eye out for vandals.
   4. Keeping solids out of the effluent.
   5. Keeping the wastewater flowing.

8. Replacement of wastewater collection systems in some downtown streets is difficult because (select only one answer, the best answer).

   1. The hills are too steep.
   2. Of the crowding of other underground utilities.
   3. Records have not been maintained properly and the collection system is lost.
   4. Some people have landscaped their backyards over the collection system and do not want their yard dug up.
   5. The streets have to be paved again.

GO ON TO NEXT PAGE

9. After a collection system problem has been solved, you should

    1. Go home.
    2. Wait until tomorrow to fill out the report forms.
    3. Take a break.
    4. Record what was done for future reference.
    5. Evaluate the effectiveness of the results.

10. Collection system workers are similar to doctors because

    1. They charge high fees.
    2. They keep good records so they can learn what kinds of solutions to problems work and don't work.
    3. They try to diagnose the cause of the problem.
    4. They prescribe pills to solve problems.
    5. They seek cures for the ills a collection system could acquire.

CHAPTER 3

WASTEWATER COLLECTION SYSTEMS

(Purpose, Components and Design)

by

Steve Goodman

NOTICE

This chapter consists of 3 topics on the purpose, components and design of wastewater collection systems from page 3-1 to page 3-47.

The SUPPLEMENT on construction, inspection and testing is provided for reference purposes, but is not required reading for collection system workers in the field study course.

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(Purpose, Components and Design)

by Steve Goodman

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(Construction, Testing and Inspection)

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OBJECTIVES

CHAPTER 3. WASTEWATER COLLECTION SYSTEMS

After completion of Chapter 3 you should be able to do the following:

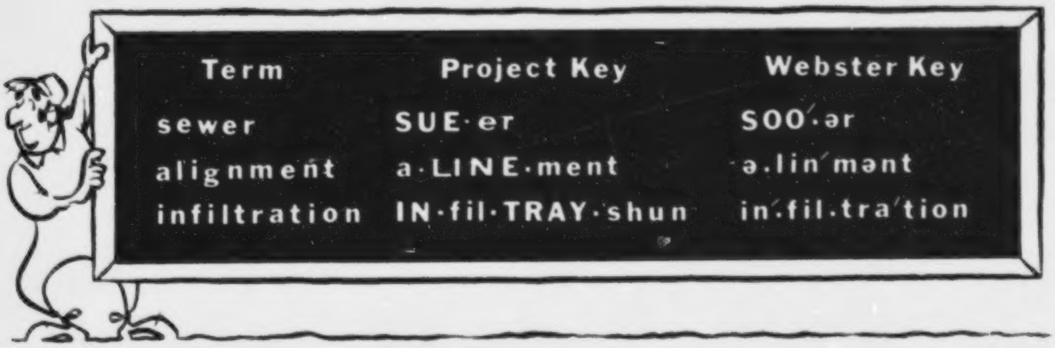
1. List the parts of a wastewater collection system and explain the purpose of each part.
2. Communicate to design engineers the need to consider operation and maintenance problems when designing collection systems.
3. Identify sources and quantities of wastewater flow.
4. Estimate the velocity of water flowing in a sewer.

Worker's Project Pronunciation Key

by Warren L. Prentice

The Worker's Project Pronunciation Key is designed to aid you in the pronunciation of new words. While this Key is based primarily on familiar sounds, it does not attempt to follow any particular pronunciation guide. This Key is designed solely to aid workers in this program.

You may find it helpful to refer to other available sources for pronunciation help. Each current standard dictionary contains a guide to its own pronunciation Key. Each Key will be different from each other and from this Key. Examples of the differences between the Key used in this program and the Webster's New World Dictionary Key, Second College Edition, 1972[1] are shown below:



Term	Project Key	Webster Key
sewer	SUE·er	SOO′·ər
alignment	a·LINE·ment	ə.lin′mənt
infiltration	IN·fil·TRAY·shun	in′.fil.tra′tion

In using this Key, you should accent (say louder) the syllable which appears in capital letters. The following chart is presented to give examples of how to pronounce words using the Worker's Project Key:

---

[1] The Webster's New World Dictionary, Second College Edition, 1972 was chosen rather than an unabridged dictionary because of its availability to most collection system workers.

	Syllable			
Word	1st	2nd	3rd	4th
sewer	SUE	er		
alignment	a	LINE	ment	
infiltration	IN	fill	TRAY	shun

The first word sewer has its first syllable accented. The second word, alignment, has its second syllable accented. The third word, infiltration, has its first and third syllables accented.

We hope you will find the Key useful in unlocking the pronunciation of any new word.

Explanation of Words

The meanings of words in the glossary of this manual are on the basis of current usage by the wastewater collection profession and definitions given in Glossary - Water and Wastewater Control Engineering, prepared by the Joint Editorial Board representing APHA, ASCE, AWWA and WPCF*, 1969. Certain words used by wastewater collection system workers tend to have slightly different meanings in some regions of the United States. We have tried to standardize word meanings as much as possible.

Appendix G, Collection System Words, is a summary of the words in the glossary at the beginning of each chapter.

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* APHA. American Public Health Association.
ASCE. American Society of Civil Engineers.
AWWA. American Water Works Association.
WPCF. Water Pollution Control Federation.

GLOSSARY

ALIGNMENT (a-LINE-ment) ALIGNMENT

Line. Location and direction of a pipeline or other line.

APPURTENANCE (a-PURR-ten-nans) APPURTENANCE

Machinery, appliances, structures and other parts of the main structure necessary to allow it to operate as intended, but not considered part of the main structure.

BACKWATER GATE BACKWATER GATE

A gate installed at the end of a drain or outlet pipe to prevent the backward flow of water or wastewater. Generally used on sewer outlets into streams to prevent backward flow during times of flood or high tide. Also called a TIDE GATE.

BARREL BARREL

(1) The cylindrical part of a pipe that may have a bell on one end.

(2) The cylindrical part of a manhole between the cone and the shelf at the bottom.

WORDS
WORDS
WORDS
ORDS

BEDDING BEDDING

The prepared base or bottom of a trench or excavation on which a pipe or other underground structure is supported.

BLOCKAGE BLOCKAGE

(1) When a collection system becomes plugged and the flow backs up, it is said to have a "blockage".

(2) The place and cause of a blockage. Example: "Fifty-one feet from a specific manhole" and "a grease blockage". Commonly called STOPPAGE.

BRANCH SEWER BRANCH SEWER

A sewer that receives wastewater from a relatively small area and discharges into a main sewer serving more than one branch-sewer area.

BUILDING SEWER BUILDING SEWER

A gravity flow pipeline connecting a building wastewater collection system to a lateral or branch sewer. The building sewer may begin at the outside of the building's foundation wall or some distance (such as 2 to 10 feet) from the wall, depending on local sewer ordinances. Also called a HOUSE CONNECTION or a SERVICE CONNECTION.

CATCH BASIN CATCH BASIN

A chamber or well used with storm or combined sewers as a means of removing grit which might otherwise enter and be deposited in sewers. Also see STORM-WATER INLET and CURB INLET.

CAULK (KAWK) CAULK

To stop up and make watertight the joints of a pipe by filling the joints with a waterproof compound or material.

CAULKING (KAWK-ing) CAULKING

(1) A waterproof compound or material used to fill a pipe joint.

(2) The act of using a waterproof compound or material to fill a pipe joint.

CLEANOUT CLEANOUT

A point of access to a wastewater collection system for insertion of tools, rods or snakes to effect pipeline cleaning.

COHESIVE (coe-HE-sive) COHESIVE

Tending to stick together.

COMBINED SEWER COMBINED SEWER

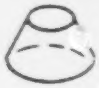
A sewer intended to receive both wastewater and storm or surface water.

COMBINED WASTEWATER COMBINED WASTEWATER

A mixture of surface runoff and other wastewater such as domestic or industrial wastewater.

CONCENTRIC MANHOLE CONE CONCENTRIC MANHOLE CONE

Cone tapers uniformly from barrel to manhole cover.



CURB INLET CURB INLET

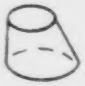
A chamber or well built at the curbline of a street to admit gutter flow to the storm water drainage system. Also see STORM WATER INLET and CATCH BASIN.

DEBRIS (de-BREE) DEBRIS

Any material in wastewater found floating, suspended or moving along the bottom of a sewer. This material may cause stoppages by getting hung up on roots or settling out in a sewer. Debris includes grit, paper, plastic, rubber, silt, and all materials except liquids.

ECCENTRIC MANHOLE CONE ECCENTRIC MANHOLE CONE

Cone tapers nonuniformly from barrel to manhole cover with one side usually being vertical.



EXFILTRATION (EX-fill-TRAY-shun) EXFILTRATION

Liquid wastes and liquid-carried waste which unintentionally leak out of a sewer pipe system and into the environment.

FLAP GATE FLAP GATE

A gate that opens and closes by rotation around a hinge or hinges at the top side of the gate.

FLOW LINE FLOW LINE

The lowest point of the channel inside a pipe or manhole. See INVERT.

FLUSHER BRANCH FLUSHER BRANCH

A line built specifically to allow the introduction of large quantities of water to the collection system so the lines can be "flushed out" with water. Also installed to provide access for equipment to clear stoppages in a sewer.

FORCE MAIN FORCE MAIN

A pipe that conveys wastewater under pressure from the discharge side of a pump to a point of gravity flow downstream.

GRIT GRIT

The heavy mineral material present in wastewater such as sand, coffee grounds, eggshells, gravel and cinders. Grit tends to settle and accumulate in the invert or bottoms of the pipelines.

HYDRAULIC GRADE LINE (HGL) HYDRAULIC GRADE LINE

The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the hydraulic grade line is at the level water would rise to in a small tube connected to the pipe. To reduce the release of odors from sewers, the water surface should be kept as smooth as possible.

INFILTRATION (IN-fill-TRAY-shun) INFILTRATION

The water entering a sewer system, including service connections, from the ground, through such means as, but not limited to, defective pipes, pipe joints, connections or manhole walls.

INFILTRATION/INFLOW INFILTRATION/INFLOW

The total quantity of water from both infiltration and inflow without distinguishing the source.

INFLOW INFLOW

The water discharged into a sewer system and service connections from such sources as, but not limited to, roof leaders, cellar, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, around manhole covers or through holes in the covers, cross connections from storm and combined sewer systems, catch basins, storm waters, surface runoff, street wash waters or drainage. See INTERNAL INFLOW.

INTERCEPTING SEWER **INTERCEPTING SEWER**

A sewer that receives flow from a number of other large sewers or outlets and conducts the waters to a point for treatment or disposal. Often called an INTERCEPTOR.

INTERNAL INFLOW **INTERNAL INFLOW**

Non-sanitary or industrial wastewaters generated inside of a domestic, commercial or industrial facility and being discharged into the sewer system. Examples are cooling tower waters, basement sump pump discharge waters, continuous-flow drinking fountains, and defective or leaking plumbing fixtures.

INVERT **INVERT**

The lowest point of the channel inside a pipe or manhole. See FLOW LINE.

INVERTED SIPHON **INVERTED SIPHON**

A pressure pipeline used to carry wastewater flowing in a gravity collection system under a depression such as a valley or roadway or under a structure such as a building. Also called a DEPRESSED SEWER.

LAMP HOLE **LAMP HOLE**

A small vertical pipe or shaft extending from the surface of the ground to a sewer. A light (or lamp) may be lowered down the pipe for the purpose of inspecting the sewer. Rarely constructed today.

LATERAL SEWER **LATERAL SEWER**

A sewer that discharges into a branch or other sewer and has no other common sewer tributary to it. Sometimes called a STREET SEWER because it collects wastewater from individual homes.

LIFT STATION LIFT STATION

A wastewater pumping station that lifts the wastewater to a higher elevation when the continuance of the sewer at reasonable slopes would involve excessive depths of trench, or that raises wastewater from areas too low to drain into available sewers. These stations may be equipped with air-operated ejectors or centrifugal pumps. Sometimes called a 'PUMP STATION'. The term 'PUMP STATION' is usually reserved for a similar type of facility that is discharging into a long 'FORCE MAIN', while a lift station has a discharge line or force main only up to the downstream gravity sewer.

MAIN LINE MAIN LINE

Branch or lateral sewers that collect wastewater from building sewers and service lines.

MAIN SEWER MAIN SEWER

A sewer line that receives wastewater from many tributary branches and sewer lines and serves as an outlet for a large territory.

MANHOLE MANHOLE

An opening in a sewer provided for the purpose of permitting workers or equipment to enter or leave a sewer. Sometimes called an ACCESS HOLE.

NOMINAL DIAMETER NOMINAL DIAMETER

Approximate diameter of a pipe; used to describe the size or diameter of a pipe.

NOMOGRAPH (NOME-o-graph) NOMOGRAPH

A graphic representation or means of solving an equation or mathematical relationship. Results are obtained with the aid of a straightedge placed over important known values.

OUTFALL OUTFALL

(1) The point, location or structure where wastewater or drainage discharges from a sewer, drain, or other conduit.

(2) The conduit leading to the ultimate disposal area. See OUTFALL SEWER.

OUTFALL SEWER OUTFALL SEWER

A sewer that receives wastewater from a collection system or from a wastewater treatment plant and carries it to a point of ultimate discharge in the environment. See OUTFALL.

OUTLET OUTLET

Downstream opening or discharge end of a pipe, culvert, or canal.

PNEUMATIC EJECTOR (NEW-MAT-tik E-JECK-tor) PNEUMATIC EJECTOR

A device for raising wastewater, sludge or other liquid by alternately admitting it through an inward-swinging check valve into the bottom of an airtight pot and then discharging it through an outward-swinging check valve by admitting compressed air to the pot above the wastewater.

SANITARY COLLECTION SYSTEM SANITARY COLLECTION SYSTEM

The pipe system for collecting and carrying liquid and liquid carried wastes from domestic sources to a wastewater treatment plant. See WASTEWATER COLLECTION SYSTEM.

SANITARY SEWER SANITARY SEWER

A sewer that carries water and water-carried wastes from residences, commercial buildings, industrial plants, and institutions, together with minor quantities of ground, storm, and surface waters that are not admitted intentionally.

SEDIMENTATION (SED-i-men-TAY-shun) SEDIMENTATION

The process of settling and depositing of suspended matter carried by wastewater, by gravity. Sedimentation usually occurs when the velocity of the wastewater is reduced below the point at which it can transport the suspended material.

SEWAGE SEWAGE

The used water and water-carried solids from homes that flow in sewers to a treatment plant. The preferred term is WASTEWATER.

SEWER SEWER

A pipe or conduit that carries wastewater or drainage water. The term COLLECTION LINE is often used also.

SEWER GAS SEWER GAS

(1) Gas evolved in sewers that results from the decomposition of organic matter in the wastewater. When testing for gases found in sewers, test for lack of oxygen and also for explosive and toxic gases.

(2) Any gas present in the wastewater collection system, even though it is from such sources as gas mains, gasoline and cleaning fluids.

SEWERAGE SEWERAGE

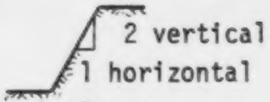
System of piping with appurtenances for collecting, conveying and treating wastewater from source to discharge.

SIPHON SIPHON

A closed conduit a portion of which lies above the hydraulic grade line, resulting in a pressure less than atmospheric and requiring a vacuum within the conduit to start flow. A siphon uses atmospheric pressure to effect or to increase the flow of water through the conduit.

SLOPE SLOPE

The slope or inclination of a sewer or trench excavation is given as the vertical to the horizontal or "rise over run".



2:1 slope

SNAKE SNAKE

A stiff, flexible cable that is inserted into sewers to clear stoppages.

SPRINGLINE SPRINGLINE

Theoretical center of a pipeline or the guide line for laying a course of bricks.

STOPPAGE STOPPAGE

(1) When a sewer system or sewer becomes plugged and the flow backs up, it is said to have a "stoppage".

(2) The place and cause of a stoppage. Example: "Fifty-one feet from a specifc manhole" and "a grease stoppage". See BLOCKAGE.

(3) Partial or complete interruption of flow as a result of some obstruction in a sewer.

STORM RUNOFF STORM RUNOFF

That portion of the total runoff that reaches the point of measurement within a relatively short period of time after the occurrence of precipitation. Also called DIRECT RUNOFF.

STORM SEWER STORM SEWER

A sewer that carries storm water and surface water, street wash and other wash waters, or drainage, but excludes domestic wastewater and industrial wastes. Also called STORM DRAIN.

STORM WATER
STORM WATER

The excess water running off from the surface of a drainage area during and immediately after a period of rain. It is that portion of the rainfall and resulting surface flow in excess of that which can be absorbed through the infiltration capacity of the surface of the basin. See STORM RUNOFF.

STORM WATER INLET
STORM WATER INLET

A device that admits surface waters to the storm water drainage system. Also see CURB INLET and CATCH BASIN.

SURFACE RUNOFF
SURFACE RUNOFF

(1) That portion of the runoff of a drainage basin that has not passed beneath the surface after deposition.

(2) The water that reaches a stream by traveling over the soil surface or falls directly into the stream channels, including not only the large permanent streams but also the tiny rills and rivulets.

(3) Water that remains after infiltration, interception, and surface storage have been deducted from precipitation.

TAP
TAP

A small hole in a sewer where a wastewater service line from a building is connected (tapped) into a lateral or branch sewer.

TIDE GATE
TIDE GATE

A gate with a flap suspended from a free-swinging horizontal hinge, usually placed at the end of a conduit discharging into a body of water having a fluctuating surface elevation. The gate is usually closed because of outside water pressure, but will open when the water head inside the pipe is large enough to overcome the outside pressure, the weight of the flap, and the friction of the hinge. Also called a BACKWATER GATE.

TOPOGRAPHY (toe-POG-gra-fee) TOPOGRAPHY

The description or features of an area, such as the hills, valleys, mountains and slope of the land surfaces.

TRUNK SEWER TRUNK SEWER

A sewer that receives many tributary branches and serves a large territory. See MAIN SEWER.

TRUNK SYSTEM TRUNK SYSTEM

A system of major sewers serving as transporting lines and not as local or lateral sewers.

U-TUBE U-TUBE

(1) A pipe shaped like a U that is constructed in a force main to raise the dissolved oxygen concentration in the wastewater.

(2) U-tube manometers are used to indicate the pressure of a gas or liquid in a confined space.

WASTEWATER WASTEWATER

The used water and water-carried solids from a community that flow to a treatment plant. Storm water, surface water, and ground water infiltration also must be included in the wastewater that enters a plant. The term SEWAGE usually refers to household wastes, but this word is being replaced by the term WASTEWATER.

WASTEWATER COLLECTION SYSTEM WASTEWATER COLLECTION SYSTEM

The pipe system for collecting and carrying water and water-carried wastes from domestic and industrial sources to a wastewater treatment plant.

WASTEWATER FACILITIES WASTEWATER FACILITIES

The pipes, conduits, structures, equipment, and processes required to collect, transport, and treat domestic and industrial wastes, and dispose of the effluent.

WASTEWATER TREATMENT PLANT WASTEWATER TREATMENT PLANT

(1) An arrangement of pipes, equipment, devices, tanks and structures for treating wastewater, industrial wastes, and sludge.

(2) A water pollution control plant.

WELL POINT WELL POINT

A perforated metal tube or screen attached to a jetting or driving head end, designed to permit the entrance of water. A well point is jetted or driven into place. Used during sewer construction to lower water table in immediate vicinity of trench.

CHAPTER 3. WASTEWATER COLLECTION SYSTEMS

3.1 PURPOSE

Persons responsible for the operation and maintenance of wastewater collection systems are not generally responsible for the design, construction and inspection of these systems. However, a basic knowledge of the components of collection systems, their purpose, and how engineers design the systems will help you do a better job; and at the same time you will become able to discuss design, construction and inspection with engineers.

Collection system workers who know how and why wastewater collection systems work, should and will be consulted by design engineers for the purpose of improving the design and construction of future systems.

Understanding how the system you will be responsible for operating and maintaining was designed and constructed also will assist you in determining the correct action to take when the system fails to operate properly. In some emergency situations you may be called upon to design and to construct a small, temporary portion for the wastewater system you are maintaining. Some collection system workers in small agencies are required to inspect sewer construction.

The purposes of a wastewater collection system are to accept, at the point of origin, water and water-carried wastes and to convey them at an acceptable rate to wastewater treatment plants. At these plants the pollutants are removed before the treated wastewater is discharged to a receiving body of water or onto land.

Wastewater collection systems are usually gravity flow systems with as few pumps and other moving parts as possible. Thus, the design and locations of the collection system are strongly influenced by the topography of the community. The steep slopes of mountainous terrain can cause problems resulting from high velocity flow. Problems include the separation of solids from wastewater and splashing and turbulence which release odors and encourage corrosion. Collection systems in flat regions can have problems caused by infiltration from groundwater and from sedimentation in the pipes resulting from low velocity flow. Sediments in a wastewater collection system can cause stoppages and allow the generation of hydrogen sulfide (a poisonous, flammable and explosive gas that encourages corrosion).

The common materials of collection systems are vitrified clay and concrete, although asbestos cement, cast iron, galvanized steel and plastic also are used widely.[1]

3.2 QUANTITIES OF WASTEWATER

From experience, designers are able to reasonably estimate the amount of wastewater that will be discharged from the population and industry plus inflow/infiltration within an area tributary to a main or trunk sewer. Table 3.1 indicates some typical wastewater discharges from different sources.

The discharge rates listed in Table 3.1 are the average for a 24-hour period. Actually the wastewater flow in a main or trunk sewer will vary considerably during a day, depending upon the habits and types of population contributing to the flow in a sewer and the lengths of the sewers. However, the pattern of daily flow shown in Figure 3.1 is fairly typical of an area with a normal mixture of residential, commercial and light industrial buildings. Relationships between average daily flows and maximum and minimum flows commonly used for dry-weather flows of domestic wastewater from areas of moderate size are:[2]

Maximum daily flow[3] = 2 x average daily flow[4]
Maximum hourly flow[5] = 1.5 x maximum daily flow, or 3 x average daily flow
Minimum daily flow[6] = 2/3 x average daily flow
Minimum hourly flow[7] = 1/2 x minimum daily flow, or 1/3 x average daily flow

---

[1] Portions of this section were taken from "Manpower Requirements for Wastewater Collection Systems in Cities and Towns up to 150,000 in Population" by Elie Namour, North Carolina A & T State University, Greensboro, North Carolina, 27411.

[2] Fair, G.M., J. C. Geyer, and D. A. Okun, "Water and Wastewater Engineering, Volume 1, Water Supply and Wastewater Removal," Wiley, New York, 1966.

[3] Maximum daily flow. Maximum flow for a 24-hour period during the entire year.

[4] Average daily flow. Average daily flow during the entire year.

[5] Maximum hourly flow. Maximum flow for a 1-hour period during the entire year.

[6] Minimum daily flow. Minimum flow for a 24-hour period during the entire year.

[7] Minimum hourly flow. Minimum flow for a 1-hour period during the entire year.

TABLE 3.1. QUANTITIES OF WASTEWATER FLOWS[a]

Type of Establishment	Gallons Per Person Per Day (Unless Otherwise Noted)
Airports (per passenger)	5
Apartments - multiple family (per resident)	60
Bathhouses and swimming pools	10
Camps:	
Campground with central comfort stations	35
With flush toilets, no showers	25
Construction camps (semi-permanent)	50
Day camps (no meals served)	15
Resort camps (night and day) with limited plumbing	50
Luxury camps	100
Cottages and small dwellings with seasonal occupancy	50
Country clubs (per resident member)	100
Country clubs (per non-resident member present)	25
Dwellings:	
Boarding houses	50
additional for non-resident boarders	10
Luxury residences and estates	150
Multiple family dwellings (apartments)	60
Rooming houses	40
Single family dwellings	75
Factories (gallons per person, per shift, exclusive of industrial wastes)	35
Hospitals (per bed space)	250
Hotels with private baths (2 persons per room)	60

(a) "MANUAL OF SEPTIC TANK PRACTICE," Public Health Service Publication No. 526, Revised 1967, U.S. Department of Health, Education and Welfare, Public Health Service, Washington, D.C. Price: 35¢.

TABLE 3.1. QUANTITIES OF WASTEWATER FLOWS (CONTINUED)

Type of Establishment	Gallons Per Person Per Day (Unless Otherwise Noted)
Hotels without private baths	50
Institutions other than hospitals (per bed space)	125
Laundries, self-service (gallons per wash, i.e., per customer)	50
Mobile home parks (per space)	250
Motels with bath, toilet, and kitchen wastes (per bed space)	50
Motels (per bed space)	40
Picnic parks (toilet wastes only) (per picknicker)	5
Picnic parks with bathhouses, showers, and flush toilets	10
Restaurants (toilet & kitchen wastes per patron)	10
Restaurants (kitchen wastes per meal served)	3
Restaurants additional for bars and cocktail lounges	2
Schools:	
Boarding	100
Day, without gyms, cafeterias, or showers	15
Day, with gyms, cafeteria, & showers	25
Day, with cafeteria, but without gyms, or showers	20
Service stations (per vehicle served)	10
Swimming pools and bathhouses	10
Theaters:	
Movie (per auditorium seat)	5
Drive-in (per car space)	5
Travel trailer parks without individual water and sewer hook-ups (per space)	50
Travel trailer parks with individual water and sewer hook-ups (per space)	100
Workers:	
Construction (at semi-permanent camps)	50
Day, at schools & offices (per shift)	15

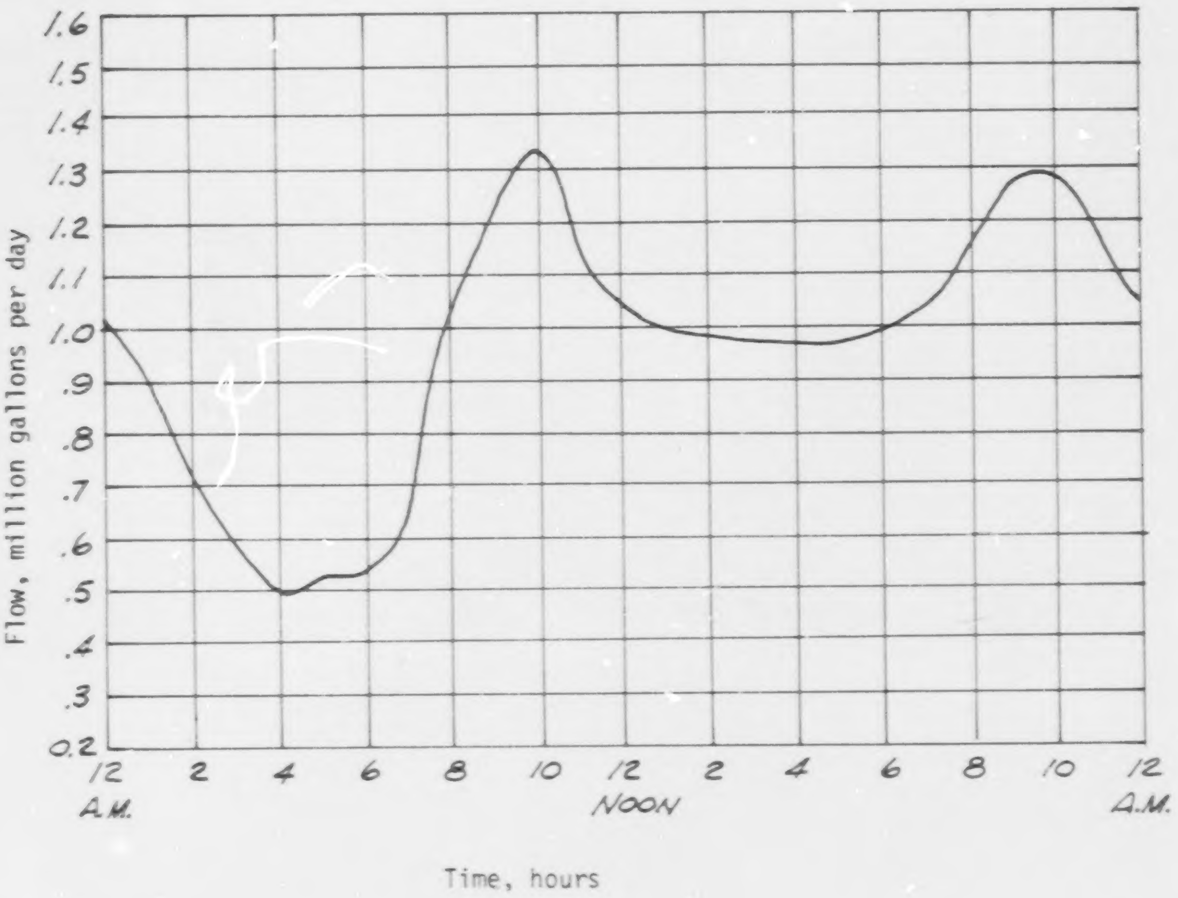


Fig. 3.1. Fluctuations of wastewater flow from a typical community

Knowledge of the wastewater flow fluctuations in a collection system can be useful in planning a wastewater collection system maintenance program. For example, collection system cleaning operations using the flow in the collection lines should be scheduled during high flows. On the other hand, cleaning with bucket equipment should be scheduled during periods of low flow.

QUESTIONS

3.1A Why should persons working on the operation and maintenance of wastewater collection systems know something about how engineers design the system?

3.1B What are the purposes of a wastewater collection system?

3.2A What are the sources of wastewater in a collection system?

3.2B Fill in the blanks for typical flows from areas of moderate size:

1. Maximum daily flow = ______ x average daily flow
2. Maximum hourly flow = ______ x average daily flow
3. Minimum daily flow = ______ x average daily flow
4. Minimum hourly flow = ______ x average daily flow

3.2C Why is it important to know the flow fluctuations in a wastewater collection system?

NOTE: Suggested answers are located at the end of Section 3.4, Design, on page 3-40.

3.3 COMPONENTS OF A WASTEWATER COLLECTION SYSTEM

Let's take a wastewater collection system apart and identify the parts and their purposes. In doing this we will start at the upper end (highest point) and follow the flow path of wastewater through the system.

3.31 Sanitary Collection System[8]

Wastewater from residences, commercial and industrial establishments is collected and conveyed to wastewater treatment plants through the following parts:

---

[8] Sanitary Collection System. The pipe system for collecting and carrying water and water-carried wastes from domestic and industrial sources to a wastewater treatment plant.

Building sewers connect to building plumbing. The building sewer may begin at the outside of the building's foundation wall or some distance (such as 2 to 10 feet) from the wall, depending on local sewer ordinances.

Lateral and branch sewers are the upper ends of the public collection system running within streets and easements collecting the wastewater from building sewers and conveying it in turn to main sewers. Figure 3.2 illustrates a typical building and lateral or branch sewer combination.

Main sewers convey the wastewater from several branch sewers serving areas of several hundred acres and convey it to larger trunk sewers.

Trunk sewers are the "backbone" of a wastewater collection system and convey the wastewater from main sewers either to a treatment plant or to intercepting sewers. These large diameter sewers are often paralleled by another trunk sewer as the service area continues to develop and the capacity of the original sewer is exceeded. Figure 3.3 illustrates a typical combination of lateral, main and trunk sewers.

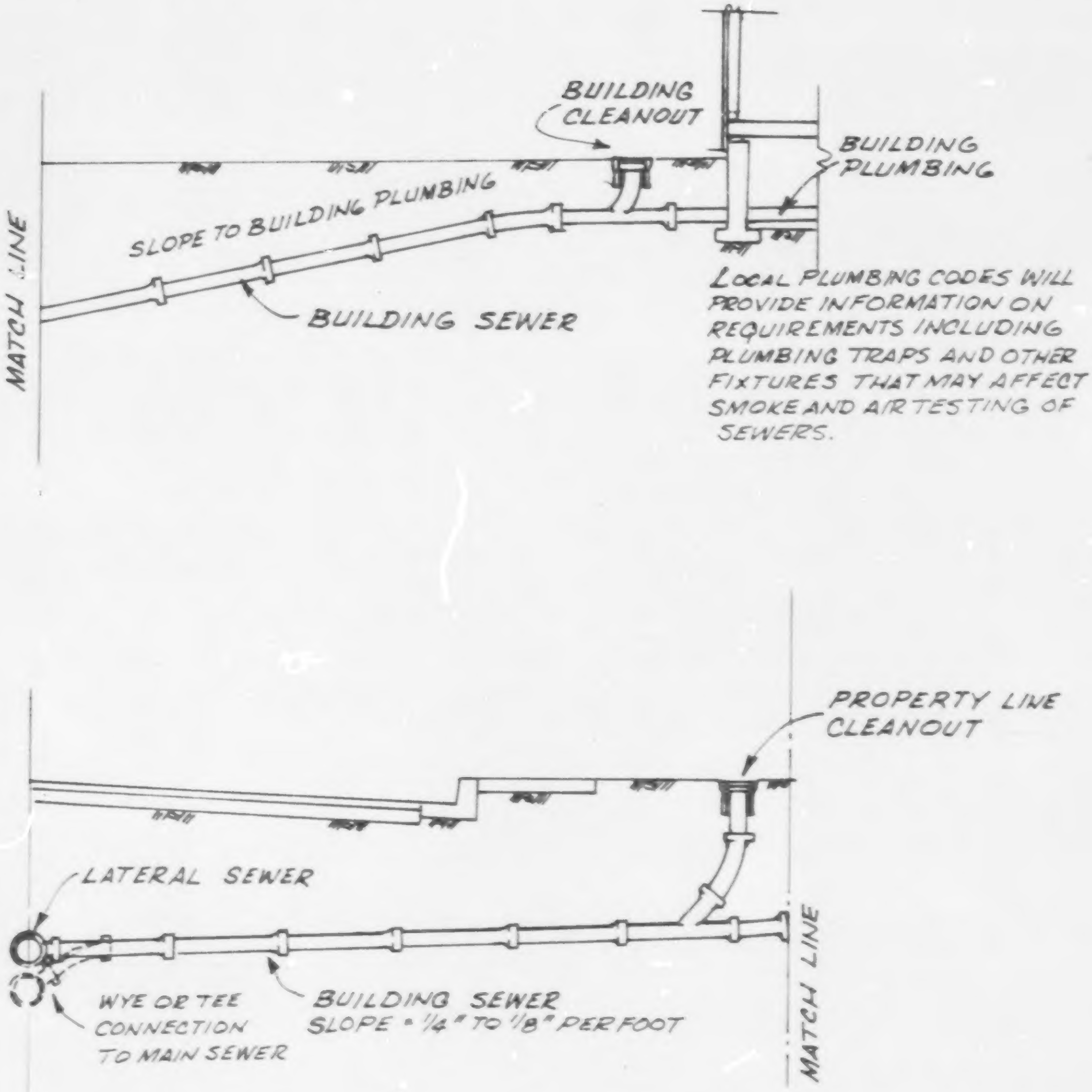
Intercepting sewers receive the wastewater from trunk sewers that previously discharged to bodies of water or to abandoned treatment plants and convey it to the operating treatment plant. Sometimes the sewer running from the lowest trunk line to the treatment plant is also called an "intercepting sewer" as illustrated in Figure 3.4.

3.32 Storm Water Collection System

Water resulting from the runoff of rainfall on urbanized areas (buildings, lots and streets) is called storm water and is conveyed through a system appropriately called a storm water collection system. This system of storm sewers also carries surface water, street wash and other wash and drainage waters. Generally, a storm water collection system has the same components as a sanitary collection system except generally there are no residential building storm drains. Figure 3.5 illustrates a typical storm water collection system.

3.33 Combined Collection System

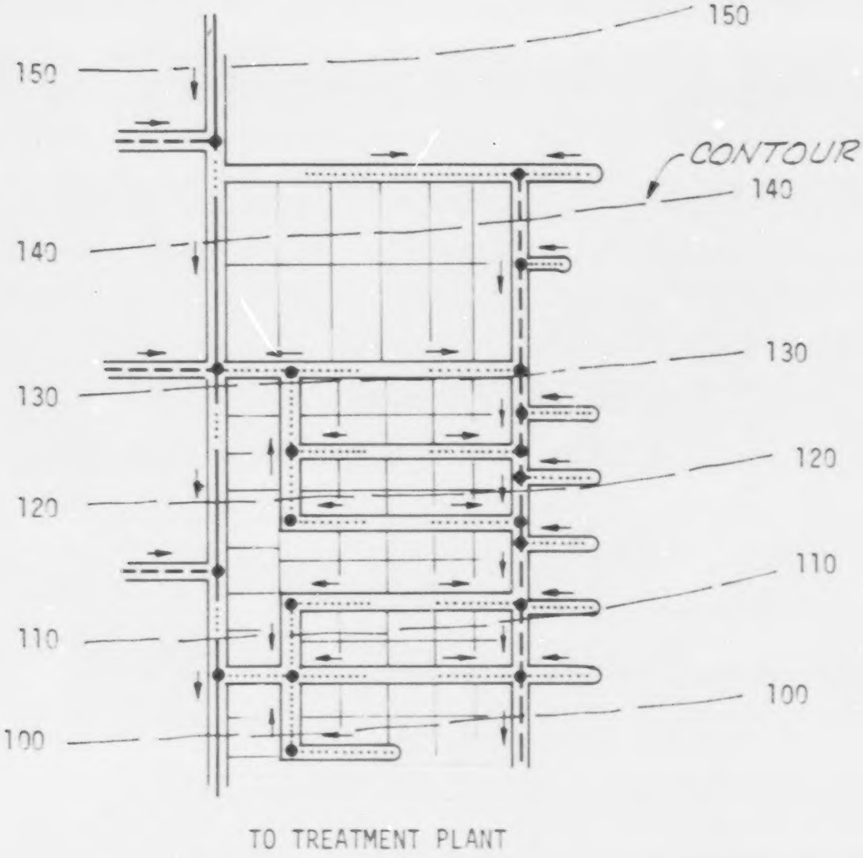
A combined collection system collects the combination of wastewater from residences, industries and businesses and storm water and surface


BUILDING CLEANOUT
BUILDING PLUMBING
SLOPE TO BUILDING PLUMBING
MATCH LINE
BUILDING SEWER
LOCAL PLUMBING CODES WILL PROVIDE INFORMATION ON REQUIREMENTS INCLUDING PLUMBING TRAPS AND OTHER FIXTURES THAT MAY AFFECT SMOKE AND AIR TESTING OF SEWERS.
PROPERTY LINE CLEANOUT
LATERAL SEWER
WYE OR TEE CONNECTION TO MAIN SEWER
BUILDING SEWER SLOPE = 1/4" TO 1/8" PER FOOT
MATCH LINE

NOTE: 1. Many agencies require a handhole or vent trap in the building sewer as in Fig. 3.12.

2. Match line means same or identical line.

Fig. 3.2. Typical building and lateral or branch sewer


150
150
CONTOUR
140
140
130
130
120
120
110
110
100
100
TO TREATMENT PLANT

LEGEND:

LATERAL/BRANCH SEWER ··········

MAIN SEWER — — — — — — — —

TRUNK SEWER —·—·—·—

MANHOLE ●

NOTE: Contour lines are lines showing equal or the same elevation.

Fig. 3.3. System of lateral, main and trunk sanitary sewers

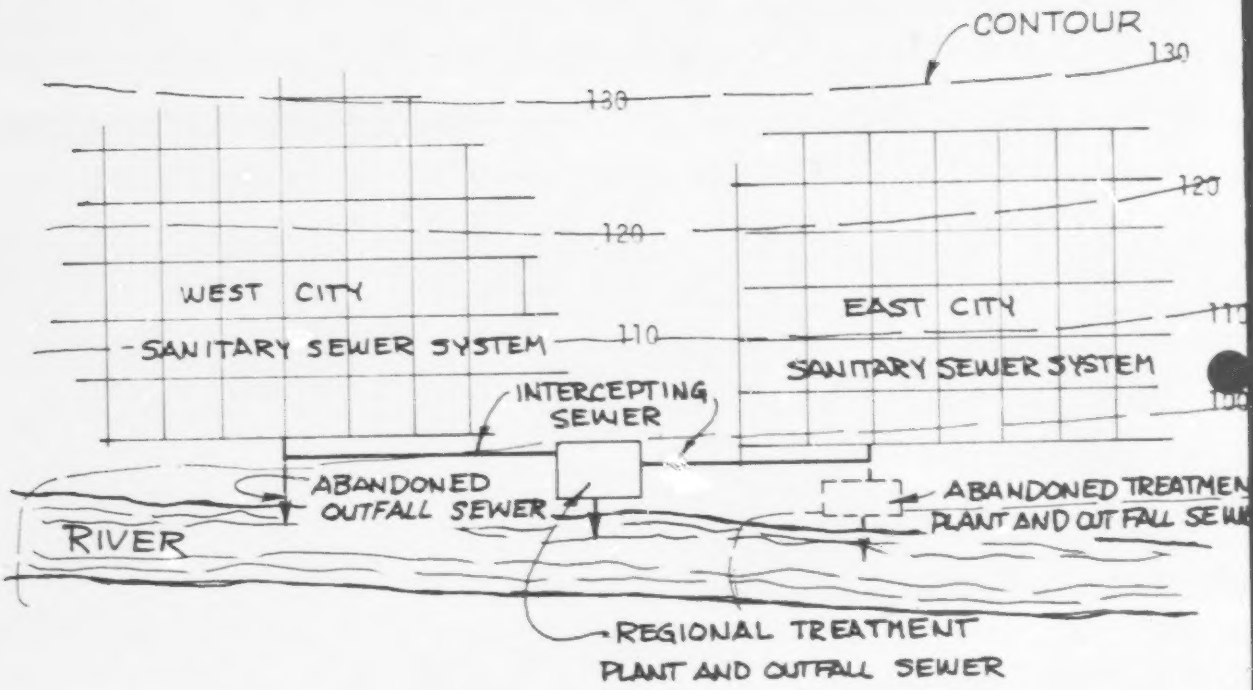

CONTOUR
130
130
120
120
WEST CITY
SANITARY SEWER SYSTEM
110
EAST CITY
SANITARY SEWER SYSTEM
INTERCEPTING SEWER
ABANDONED OUTFALL SEWER
ABANDONED TREATMEN
PLANT AND OUT FALL SE
RIVER
REGIONAL TREATMENT PLANT AND OUTFALL SEWER

Fig. 3.4. Typical intercepting sewers

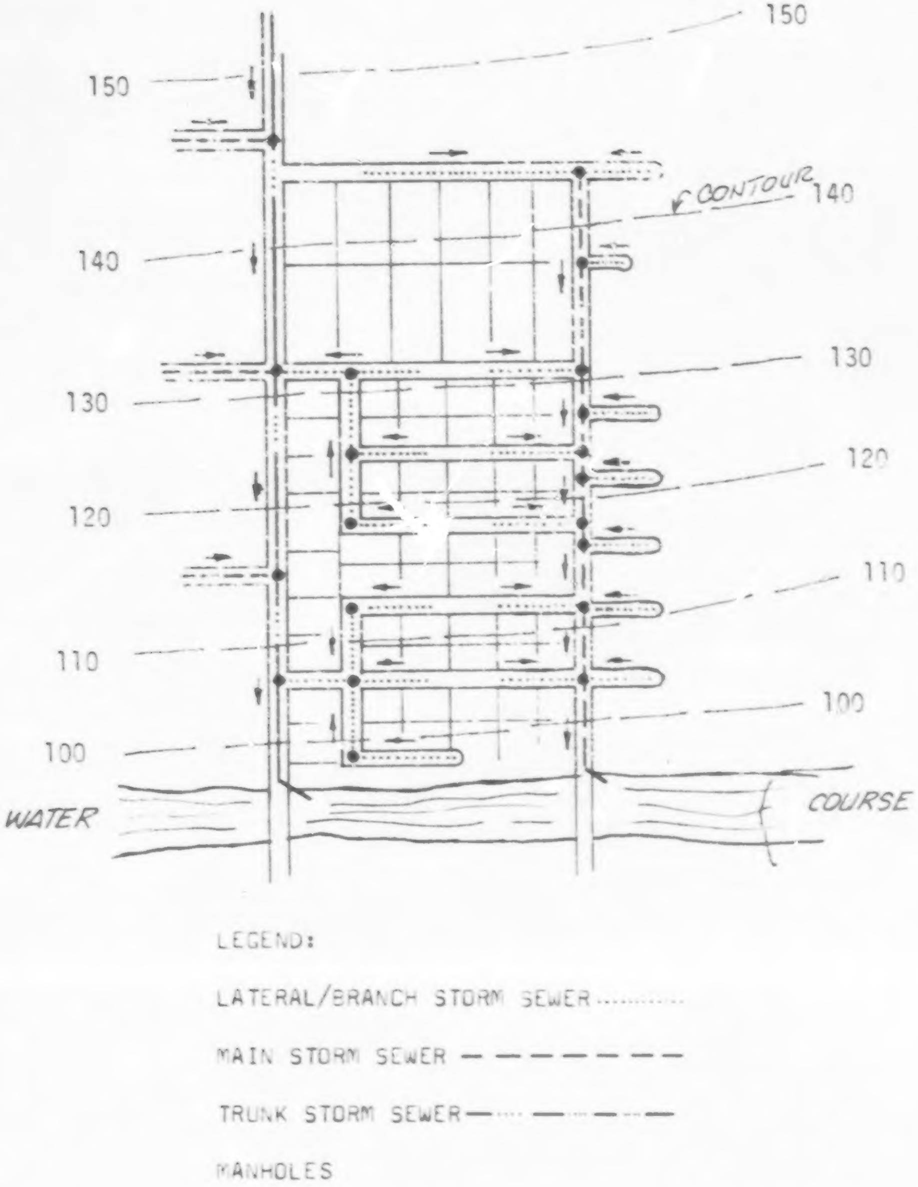

150
150
CONTOUR
140
140
130
130
120
120
110
110
100
100
WATER
COURSE
LEGEND:
LATERAL/BRANCH STORM SEWER ....
MAIN STORM SEWER — — — — — — —
TRUNK STORM SEWER —·····—·····—
MANHOLES

Fig. 3.5. System of lateral, main and trunk storm sewers

water from the same area. The entire wastewater flow in a combined collection system is conveyed to a treatment plant during dry weather. When it rains, the combined flow of wastewater from residences, industries and businesses and surface runoff from the rain is usually treated differently than dry weather flows because the volume of water is greater and the dilution effect of the storm water can be used.

3.34 Appurtenances[9]

Appurtenances to sanitary and storm water collection systems connect the separate parts of the system to each other and provide for the access of workers and equipment to the sewers for cleaning and maintenance.

Backflow preventers are used to stop the accidental backflow of wastewater into buildings and function by either allowing backflowing wastewater to flow out of a building sewer at a point lower than the building plumbing fixtures (overflow type) or by blocking the backflow to the building sewer by a one-way flapper seal (check valve type). The types and locations of backflow preventers are illustrated in Figure 3.6.

Catch basins (Figure 3.7) are used with storm and combined sewers as a means of removing grit which might otherwise enter and be deposited in sewers. They are effective only in areas with considerable street debris.

Cleanouts. Building codes should require a cleanout where the building plumbing connects to the building sewer. This point is usually located just outside of the building foundation. In very cold climates cleanouts are located in the inside wall of basements to allow convenient access in the winter. Also sewers leave homes at depths of 7 to 8 feet below ground surface to prevent freezing. Figures 3.8 and 3.9 illustrate the types and locations of cleanouts. A cleanout also should be mandatory on every building sewer where it crosses the property line as shown in Figure 3.2 for ease in clearing stoppages and maintaining the sewer. Regulations regarding the location of cleanouts and who has responsibility for maintenance vary with different communities.

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[9] Appurtenances (a-PURR-ten-nans-ses). Machinery, appliances, structures and other parts of the main structure necessary to allow it to operate as intended, but not considered part of the main structure.

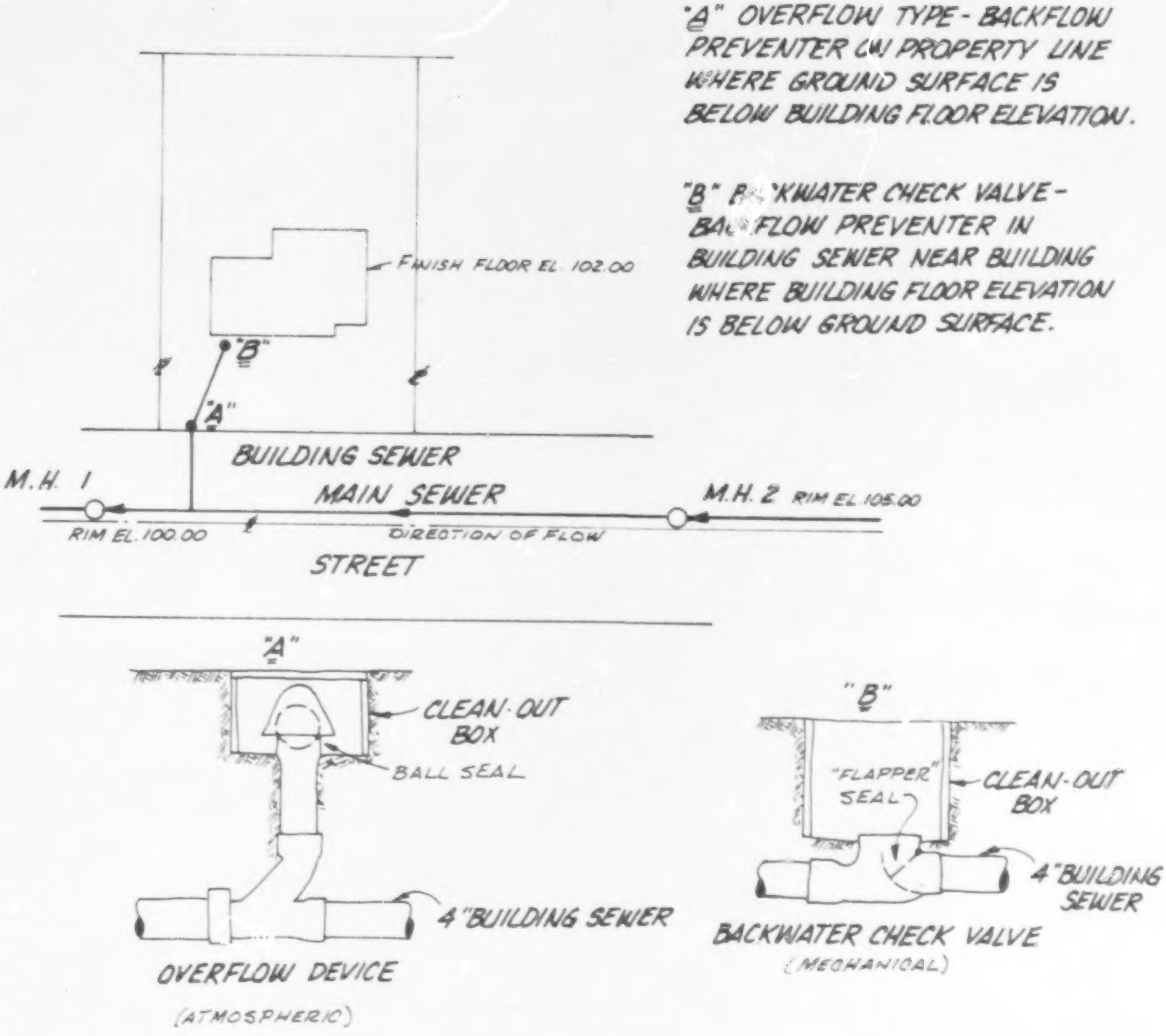
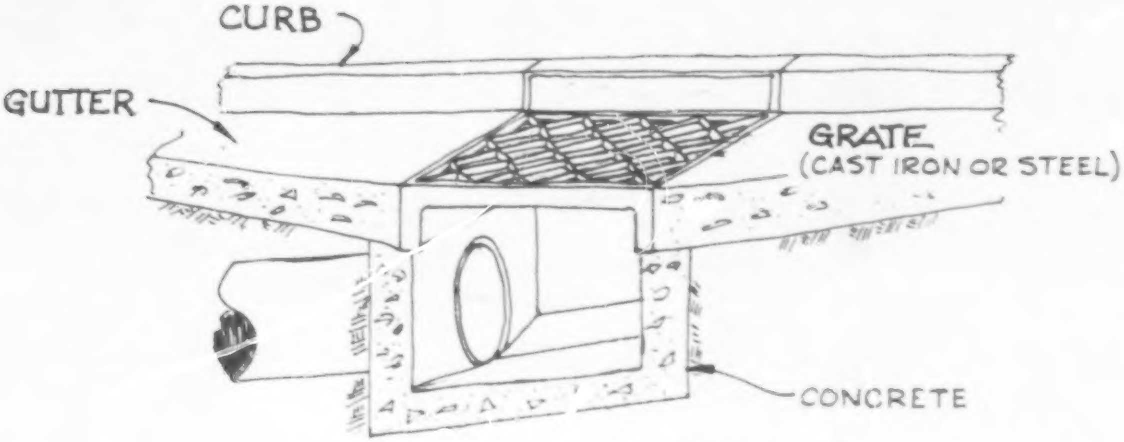
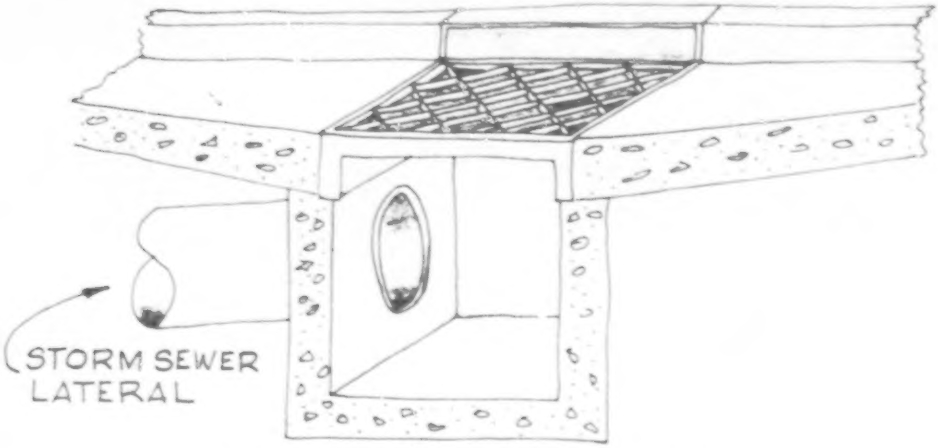

"A" OVERFLOW TYPE - BACKFLOW PREVENTER ON PROPERTY LINE WHERE GROUND SURFACE IS BELOW BUILDING FLOOR ELEVATION.
"B" BACKWATER CHECK VALVE - BACKFLOW PREVENTER IN BUILDING SEWER NEAR BUILDING WHERE BUILDING FLOOR ELEVATION IS BELOW GROUND SURFACE.
FINISH FLOOR EL. 102.00
"B"
"A"
BUILDING SEWER
M.H. 1
MAIN SEWER
M.H. 2 RIM EL. 105.00
RIM EL. 100.00
DIRECTION OF FLOW
STREET
"A"
CLEAN-OUT BOX
BALL SEAL
4" BUILDING SEWER
OVERFLOW DEVICE
(ATMOSPHERIC)
"B"
"FLAPPER" SEAL
CLEAN-OUT BOX
4" BUILDING SEWER
BACKWATER CHECK VALVE
(MECHANICAL)

Fig. 3.6. Location and type of wastewater backflow preventers

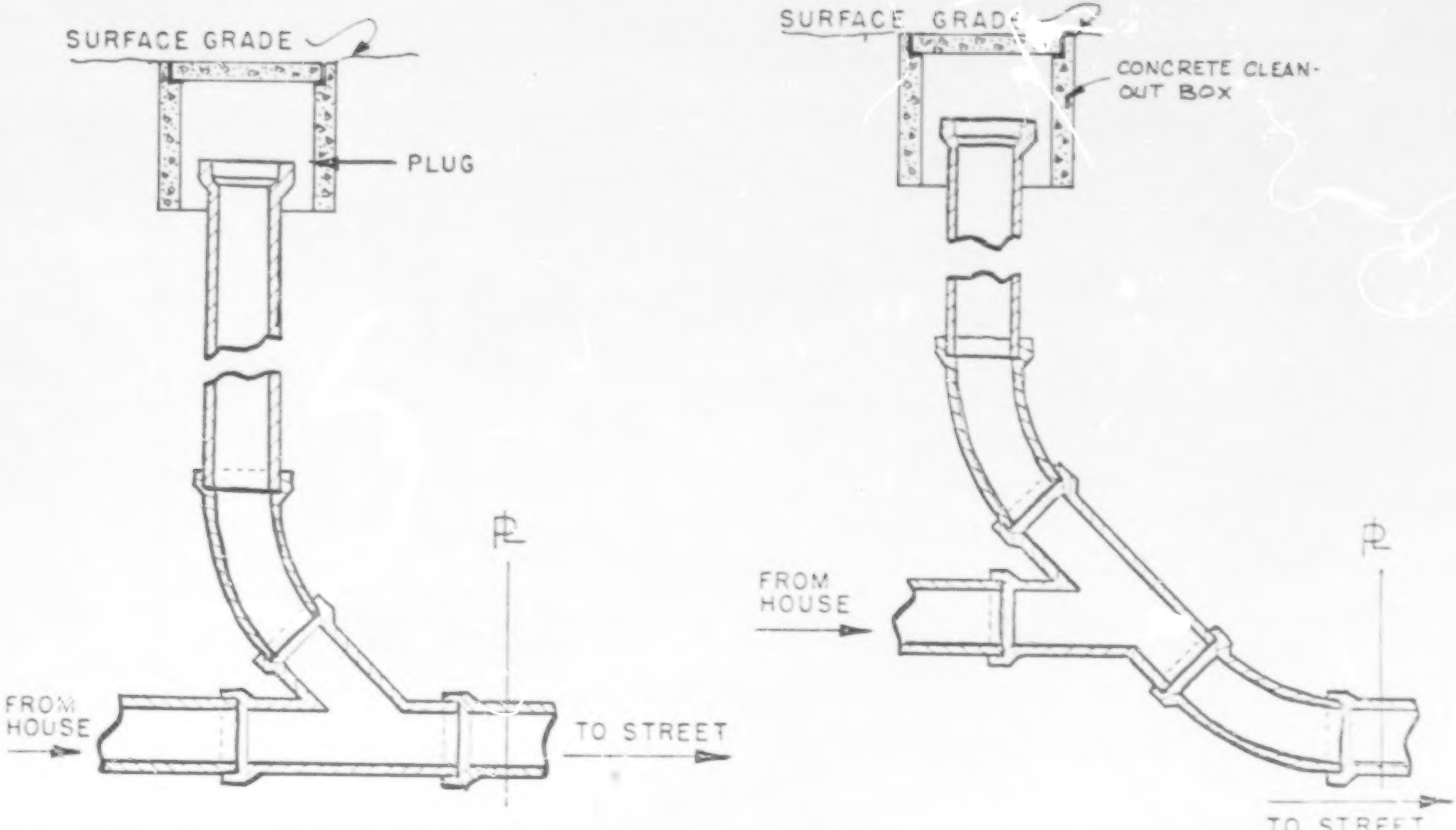

CURB
GUTTER
GRATE
(CAST IRON OR STEEL)
CONCRETE

CURB INLET WITHOUT SUMP


STORM SEWER
LATERAL

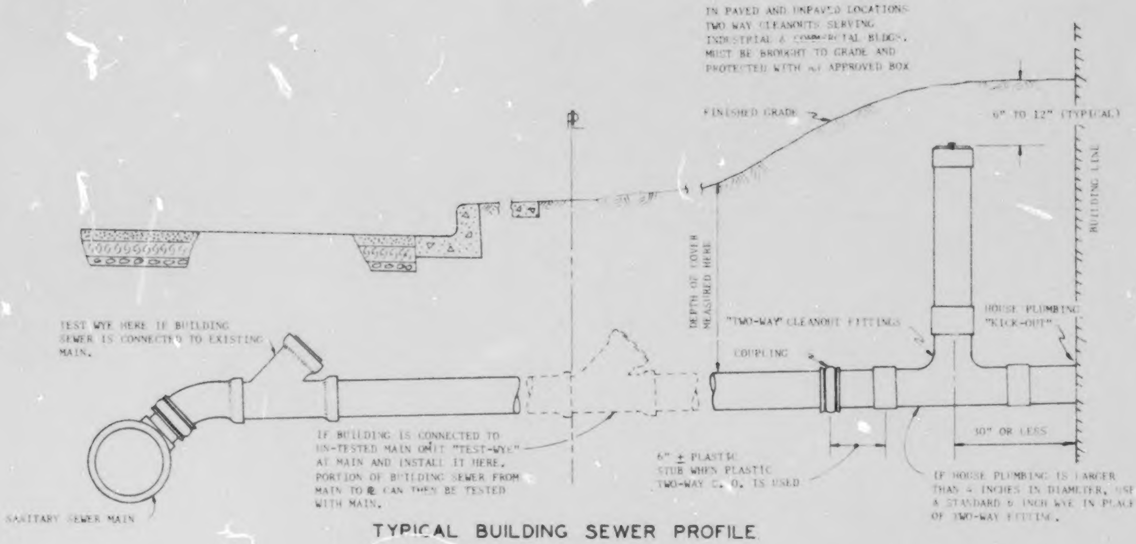
CURB INLET WITH SUMP

Fig. 3.7. Curb inlets and catch basin

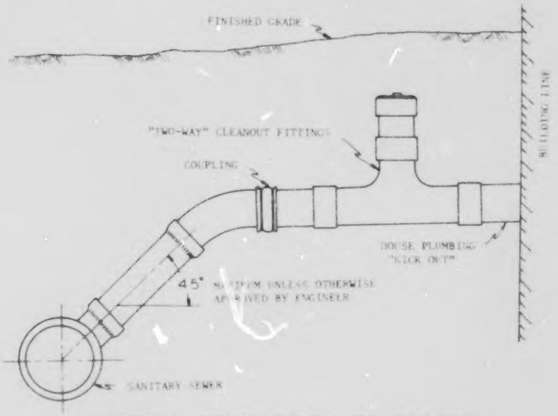

SURFACE GRADE
PLUG
FROM HOUSE
TO STREET
PL
SURFACE GRADE
CONCRETE CLEAN-OUT BOX
PL
FROM HOUSE
TO STREET

NOTE: P.L. means Property Line.

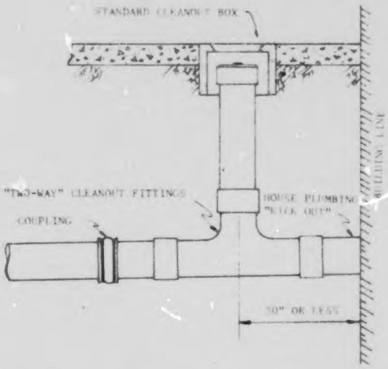
Fig. 3.8. Sewer cleanouts


IN PAVED AND UNPAVED LOCATIONS TWO WAY CLEANOUTS SERVING INDUSTRIAL & COMMERCIAL BLDGS. MUST BE BROUGHT TO GRADE AND PROTECTED WITH AN APPROVED BOX
FINISHED GRADE
6" TO 12" (TYPICAL)
BUILDING LINE
DEPTH OF COVER MEASURED HERE
"TWO-WAY" CLEANOUT FITTINGS
HOUSE PLUMBING "KICK-OUT"
COUPLING
TEST WYE HERE IF BUILDING SEWER IS CONNECTED TO EXISTING MAIN.
IF BUILDING IS CONNECTED TO UN-TESTED MAIN OMIT "TEST-WYE" AT MAIN AND INSTALL IT HERE. PORTION OF BUILDING SEWER FROM MAIN TO ℄ CAN THEN BE TESTED WITH MAIN.
6" ± PLASTIC STUB WHEN PLASTIC TWO-WAY C. O. IS USED
30" OR LESS
IF HOUSE PLUMBING IS LARGER THAN 4 INCHES IN DIAMETER, USE A STANDARD 6 INCH WYE IN PLACE OF TWO-WAY FITTING.
SANITARY SEWER MAIN

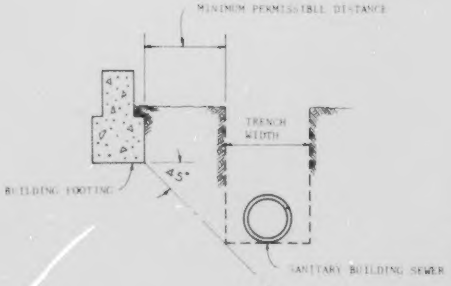
TYPICAL BUILDING SEWER PROFILE


FINISHED GRADE
BUILDING LINE
"TWO-WAY" CLEANOUT FITTINGS
COUPLING
HOUSE PLUMBING "KICK OUT"
45° MINIMUM UNLESS OTHERWISE APPROVED BY ENGINEER
SANITARY SEWER

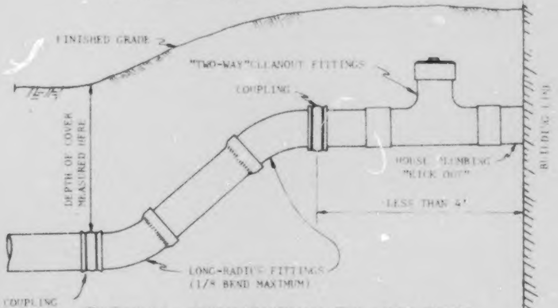
TYPICAL CONNECTION TO DEEPER LONGITUDINAL BUILDING SEWER.


STANDARD CLEANOUT BOX
BUILDING LINE
"TWO-WAY" CLEANOUT FITTINGS
HOUSE PLUMBING "KICK OUT"
COUPLING
30" OR LESS

TYPICAL "TWO-WAY" CLEANOUT TO GRADE
(ALL RESIDENTIAL USES WHEN UNDER PAVING AND/OR COVERED AREA; AND FOR ALL INDUSTRIAL AND COMMERCIAL USES.)


MINIMUM PERMISSIBLE DISTANCE
TRENCH WIDTH
45°
BUILDING FOOTING
SANITARY BUILDING SEWER

DETAIL – BUILDING SEWER ADJACENT TO BUILDING FOOTING.


FINISHED GRADE
"TWO-WAY" CLEANOUT FITTINGS
COUPLING
BUILDING LINE
DEPTH OF COVER MEASURED HERE
HOUSE PLUMBING "KICK OUT"
LESS THAN 4'
LONG-RADIUS FITTINGS (1/8 BEND MAXIMUM)
COUPLING

TYPICAL CONNECTION TO BUILDING SEWER WHERE ADDITIONAL DEPTH IS REQUIRED.

NOTES:
1. Cleanouts should be extended to surface so they are accessible without excavation in order to reduce maintenance costs and customer complaints regarding workers messing up their yards.
2. "Two-Way" cleanout fittings may be difficult to push equipment through because of the right-angle entrance instead of a gradual entrance.

Fig. 3.9. Location of Cleanouts
(Courtesy of Union Sanitary District, Alameda County, California)

The main purposes of a cleanout are to provide:

1. An inspection point to help service crews determine the location of a problem in a building sewer.
2. Access to the building sewer for clearing stoppages between the property line and the lateral sewer without tearing up a street or rear easement.

Curb inlets serve the same purpose as storm water catch basins, except they do not have sumps at the bottom to catch heavy materials. Curb inlets with and without sumps or catch basins are illustrated by Figure 3.7.

Flow regulators range from simple "stop boards" placed in pre-formed slots in a manhole base to sophisticated equipment which directs the sanitary wastewater flow in a combined collection system to a treatment plant during dry weather and diverts combined wastewater and storm water flows beyond the capacity of the treatment plant to by-pass lines and special methods of treatment during periods of rainfall. Figures 3.10 and 3.11 illustrate two types of flow regulators. The mechanical type of regulator requires frequent and thorough maintenance of its many components.

Flusher branches are lines built specifically to allow the introduction of large quantities of water to the collection system so the lines can be "flushed out" with water.

Handhole or vent traps[10] (Figure 3.12) are made of pipe fittings and can be serviced only by hand tools or hand operated equipment. These traps are usually located near the street in a building sewer to form a water barrier to prevent sewer gases escaping from the branch or lateral sewer from entering a building sewer. Required on inside plumbing in most areas.

Interconnectors are sewers that are installed to connect two separate sewers. If one sewer becomes blocked, wastewater can back up and flow through the interconnector to the other sewer. An advantage is that the backed-up wastewater will not flow into homes or down the streets. A disadvantage is that you may not know a stoppage exists until you receive odor complaints.

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[10] Also called Main Trap or House Trap.

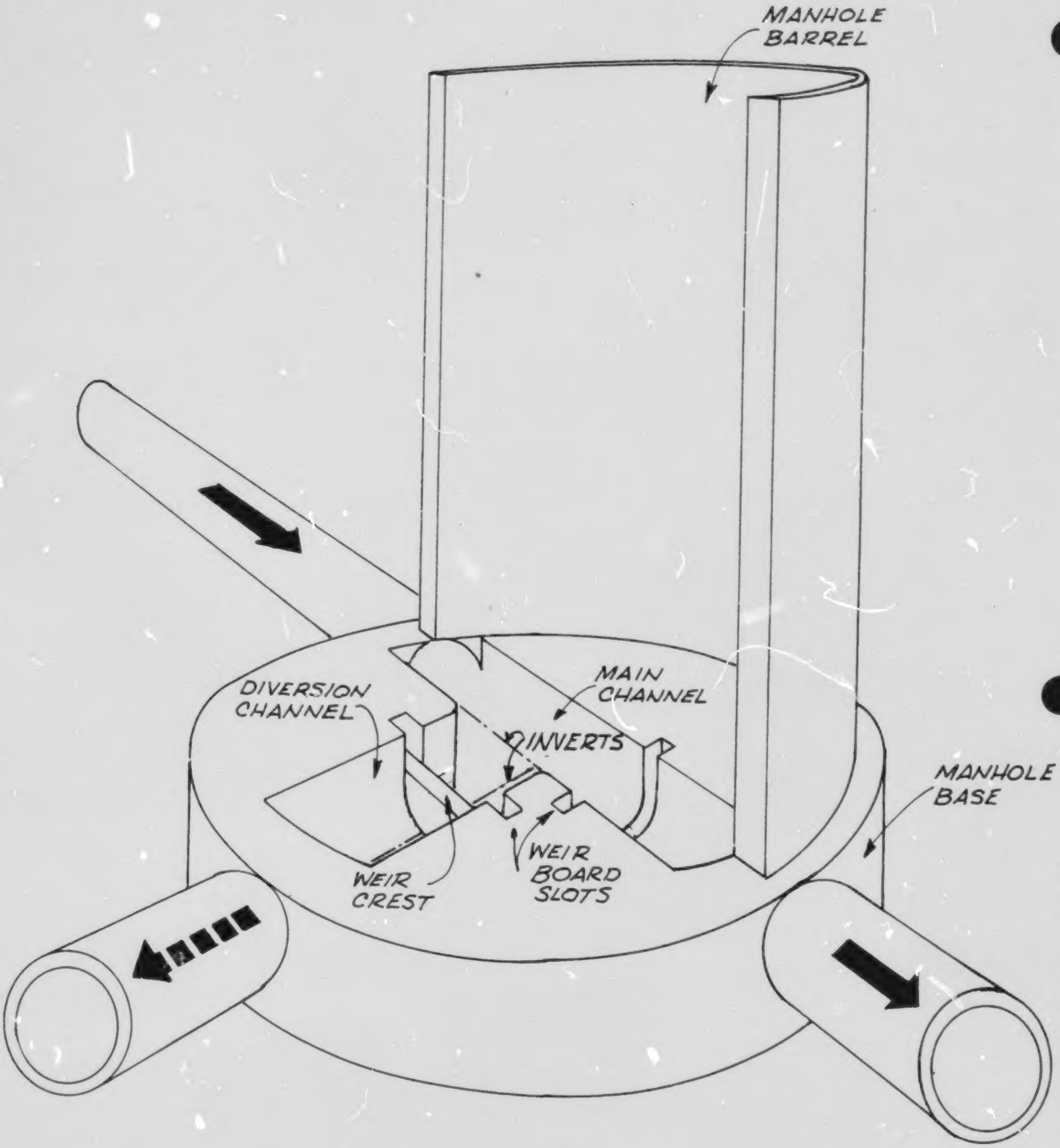

MANHOLE BARREL
DIVERSION CHANNEL
MAIN CHANNEL
INVERTS
MANHOLE BASE
WEIR CREST
WEIR BOARD SLOTS

Fig. 3.10. Typical weir type flow regulator

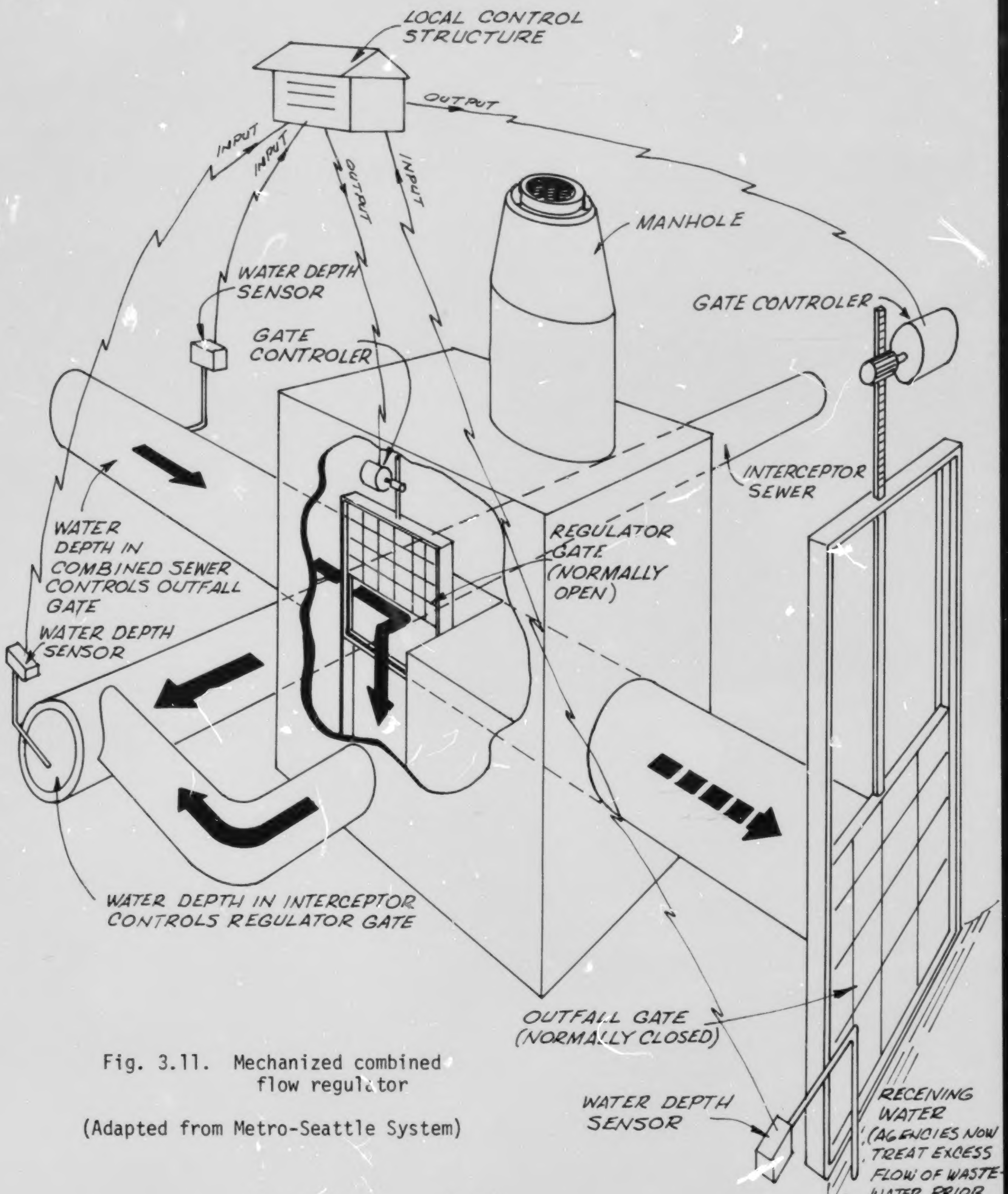

LOCAL CONTROL STRUCTURE
OUTPUT
INPUT
INPUT
OUTPUT
INPUT
MANHOLE
WATER DEPTH SENSOR
GATE CONTROLER
GATE CONTROLER
INTERCEPTOR SEWER
REGULATOR GATE (NORMALLY OPEN)
WATER DEPTH IN COMBINED SEWER CONTROLS OUTFALL GATE
WATER DEPTH SENSOR
WATER DEPTH IN INTERCEPTOR CONTROLS REGULATOR GATE
OUTFALL GATE (NORMALLY CLOSED)
WATER DEPTH SENSOR
RECEIVING WATER (AGENCIES NOW TREAT EXCESS FLOW OF WASTE-WATER PRIOR TO DISCHARGE.)

Fig. 3.11. Mechanized combined flow regulator

(Adapted from Metro-Seattle System)

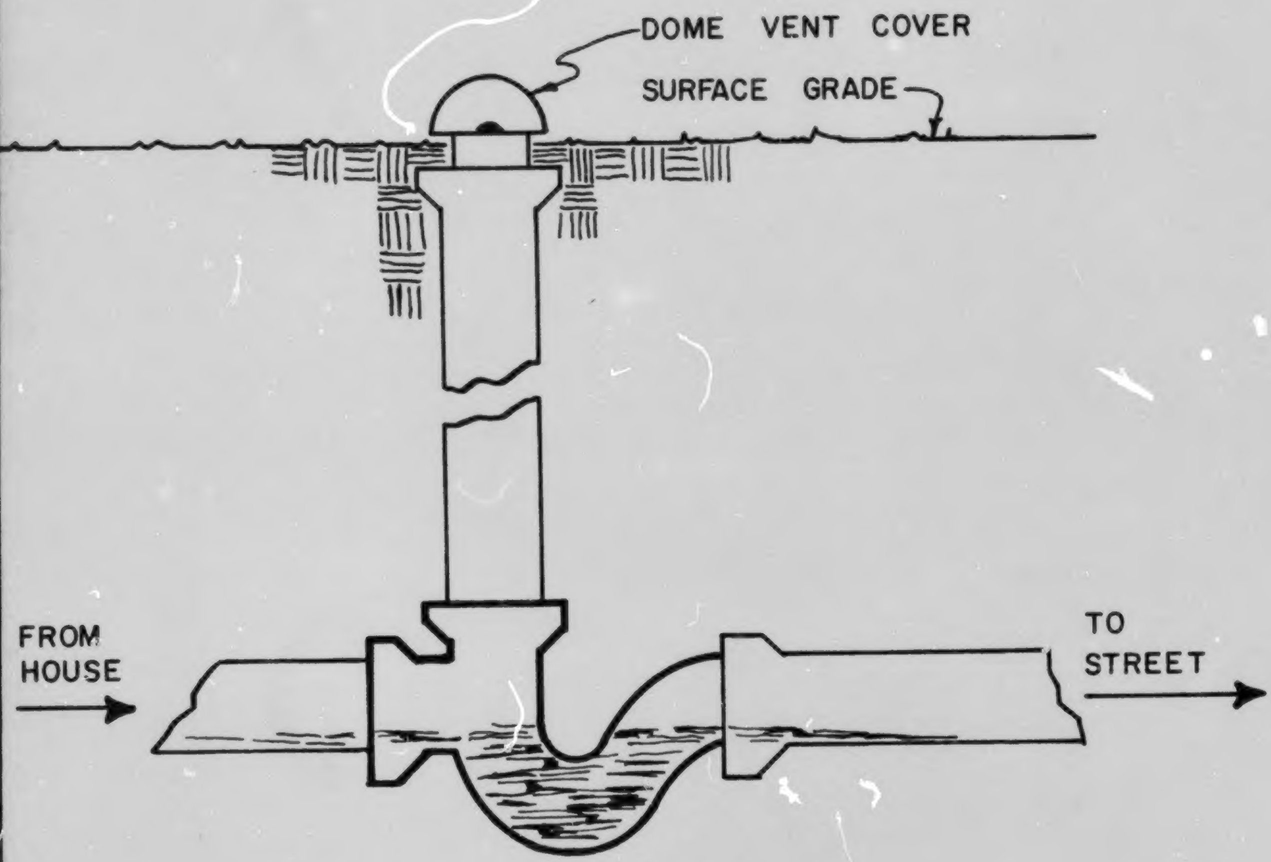

DOME VENT COVER
SURFACE GRADE
FROM HOUSE
TO STREET

Fig. 3.12. Handhole or vent trap

Inverted siphons are pressure pipelines used to carry wastewater flowing in a gravity collection system under a depression such as a valley or roadway or under a structure such as a building (Figure 3.13). Inverted siphons are designed so the flow velocity is high enough to minimize the settling of solids in the bottom of the siphon. They usually depend on peak flows to flush out solids that settle during low flows.

Junction structures are used at the intersection of large trunk and intercepting sewers to provide for the diversion of the flow from one sewer to the other as shown in Figure 3.14. Flow through the structure should not cause turbulence in the flow or hinder the incoming flows.

Lamp holes are small vertical pipes or shafts extending from the surface of the ground to a sewer, in which a light may be lowered for the purpose of inspection. Rarely constructed today.

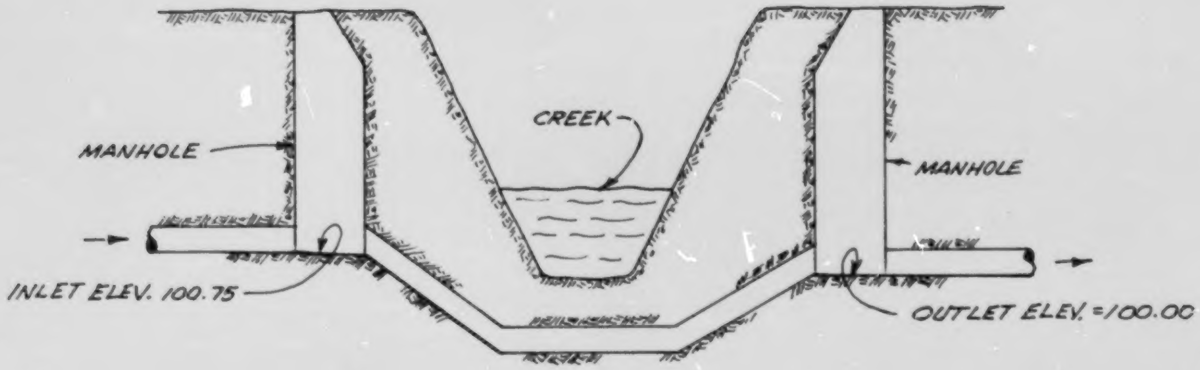
Lift stations are used, when gravity can no longer be used to convey wastewater through a sewer, to lift the wastewater to a higher elevation where gravity can again be used to convey the wastewater as illustrated by Figure 3.15.

Manholes (Figure 3.16) are provided to allow access to the sewer by workers and equipment for the purposes of inspection, cleaning and in some instances diversion of the wastewater flow. They also serve as junction structures for main and trunk sewers as illustrated by Figure 3.3. Manholes also are installed where sewers change direction, elevation or slope to provide for smooth flow and access should a stoppage occur at these critical points.

Taps are small holes in sewers where building sewers are connected (tapped) into a lateral or branch sewer and where a wye or tee connection was not installed at the time the lateral or branch sewer was constructed. Commonly all points where a building sewer is connected to a lateral are referred to as the 'Tap'.

Vertical and slanted risers are placed at the ends of lateral or branch sewers to provide an entrance to these lines for cleaning equipment and water for flushing as illustrated by Figures 3.17 and 3.18.

Wyes and tees are generally constructed as a part of the lateral, branch or main sewer pipe and facilitate the connection of the building sewer to these sewers as illustrated in Figure 3.2.


CREEK
MANHOLE
MANHOLE
INLET ELEV. 100.75
OUTLET ELEV. =100.00

NOTE: INVERTED SIPHONS ARE ALSO USED TO PASS WASTEWATER UNDER OTHER TYPES OF SUBSURFACE OBSTRUCTIONS TO GRAVITY FLOW SYSTEMS.

Fig. 3.13. Inverted siphon

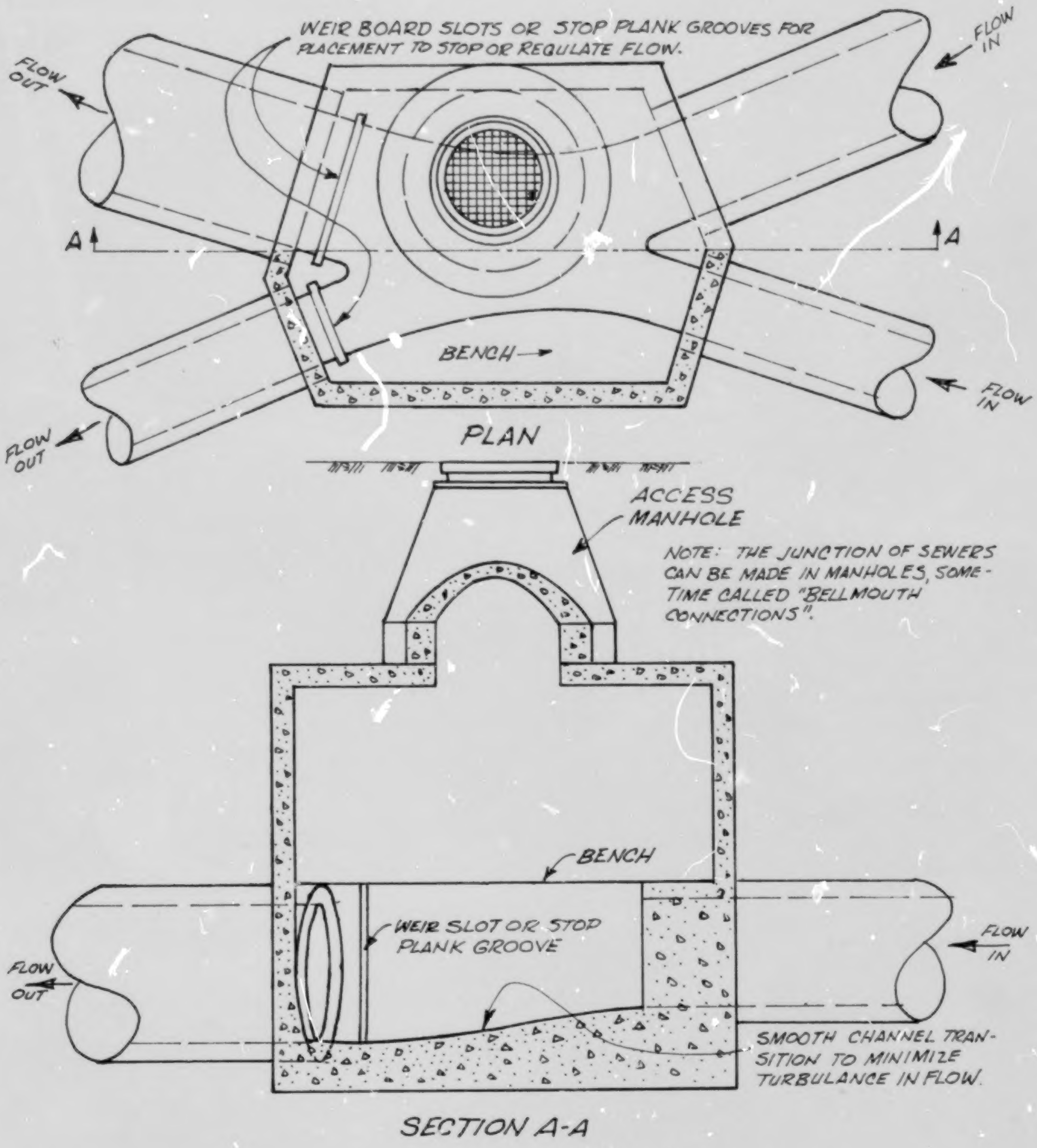
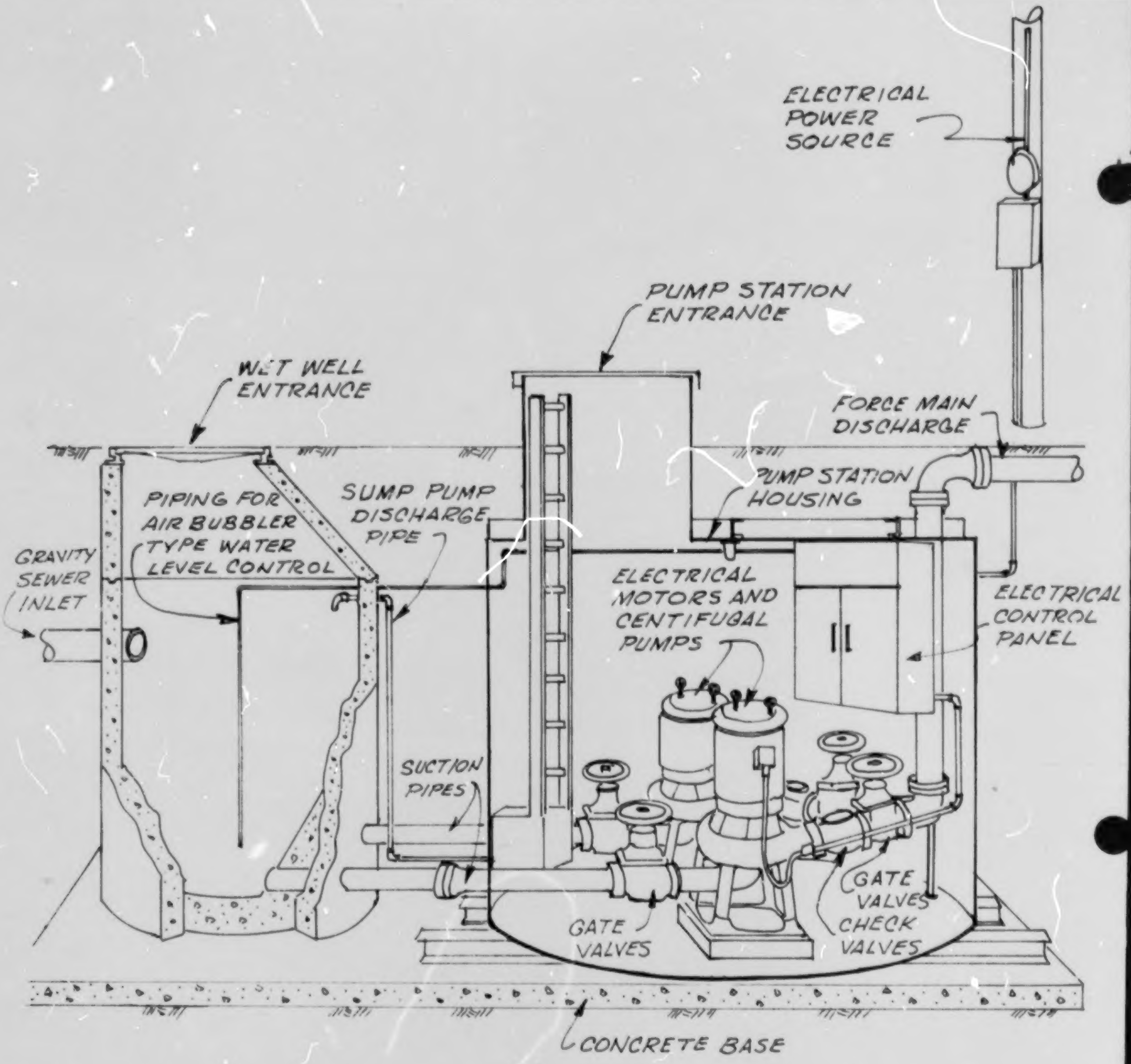

WEIR BOARD SLOTS OR STOP PLANK GROOVES FOR PLACEMENT TO STOP OR REGULATE FLOW.
FLOW OUT
FLOW IN
A
A
BENCH
FLOW IN
FLOW OUT
PLAN
ACCESS MANHOLE
NOTE: THE JUNCTION OF SEWERS CAN BE MADE IN MANHOLES, SOMETIME CALLED "BELLMOUTH CONNECTIONS".
BENCH
WEIR SLOT OR STOP PLANK GROOVE
FLOW IN
FLOW OUT
SMOOTH CHANNEL TRANSITION TO MINIMIZE TURBULANCE IN FLOW.
SECTION A-A

Fig. 3.14. Junction structure


ELECTRICAL POWER SOURCE
PUMP STATION ENTRANCE
WET WELL ENTRANCE
FORCE MAIN DISCHARGE
PUMP STATION HOUSING
PIPING FOR AIR BUBBLER TYPE WATER LEVEL CONTROL
SUMP PUMP DISCHARGE PIPE
GRAVITY SEWER INLET
ELECTRICAL MOTORS AND CENTIFUGAL PUMPS
ELECTRICAL CONTROL PANEL
SUCTION PIPES
GATE VALVES
GATE VALVES
CHECK VALVES
CONCRETE BASE

NOTE: 1. The two systems of pumps and motors provides standby facilities if one of the systems should fail to operate.
2. Lift station also should have a sump and sump pump and ventilation facilities.

Fig. 3.15. Pre-fabricated wastewater lift station

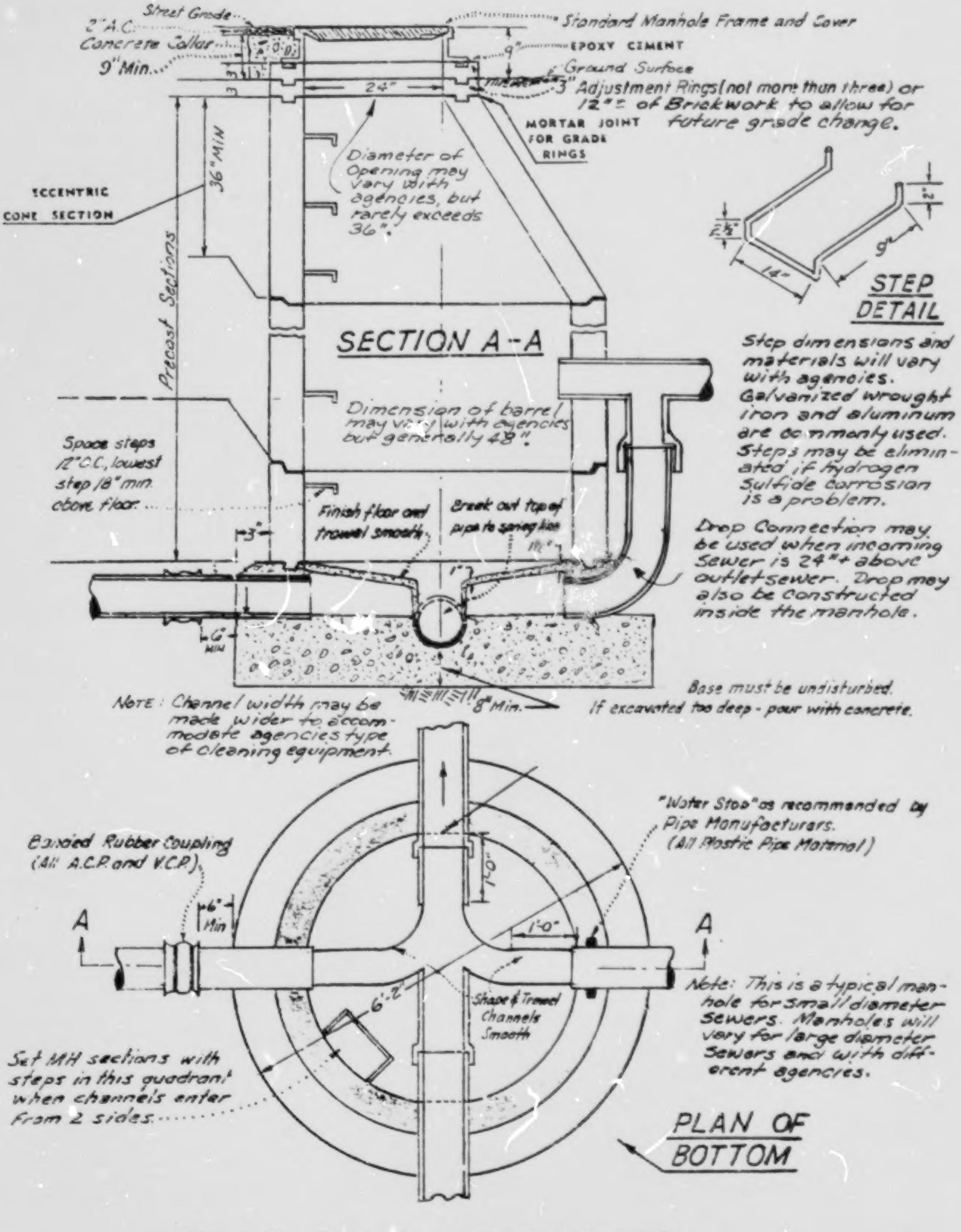

Street Grade
2" A.C.
Concrete Collar
9" Min.
Standard Manhole Frame and Cover
EPOXY CEMENT
9"
Ground Surface
3" Adjustment Rings (not more than three) or 12" ± of Brickwork to allow for future grade change.
MORTAR JOINT FOR GRADE RINGS
24"
3
3
36" MIN
ECCENTRIC CONE SECTION
Diameter of Opening may vary with agencies, but rarely exceeds 36".
Precast Sections
SECTION A-A
Dimension of barrel may vary with agencies but generally 48".
Space steps 12" C.C., lowest step 18" min. above floor.
3"
Finish floor and trowel smooth
Break out top of pipe to spring line
1"
6" MIN
8" Min.
Note: Channel width may be made wider to accommodate agencies type of cleaning equipment.
Base must be undisturbed. If excavated too deep - pour with concrete.
Drop Connection may be used when incoming Sewer is 24" + above outlet sewer. Drop may also be constructed inside the manhole.
2 1/2"
14"
9"
2"
STEP DETAIL
Step dimensions and materials will vary with agencies. Galvanized wrought iron and aluminum are commonly used. Steps may be eliminated if hydrogen Sulfide corrosion is a problem.
Banded Rubber Coupling (All A.C.P. and V.C.P.)
6" Min
A
A
1'-0"
1'-0"
"Water Stop" as recommended by Pipe Manufacturers. (All Plastic Pipe Material)
6'-2"
Shape & Trowel Channels Smooth
Set MH sections with steps in this quadrant when channels enter from 2 sides.
Note: This is a typical manhole for small diameter sewers. Manholes will vary for large diameter sewers and with different agencies.
PLAN OF BOTTOM

Fig. 3.16. Standard precast concrete manhole

(Courtesy of County Sanitation District No. 4,
Santa Clara County, California)

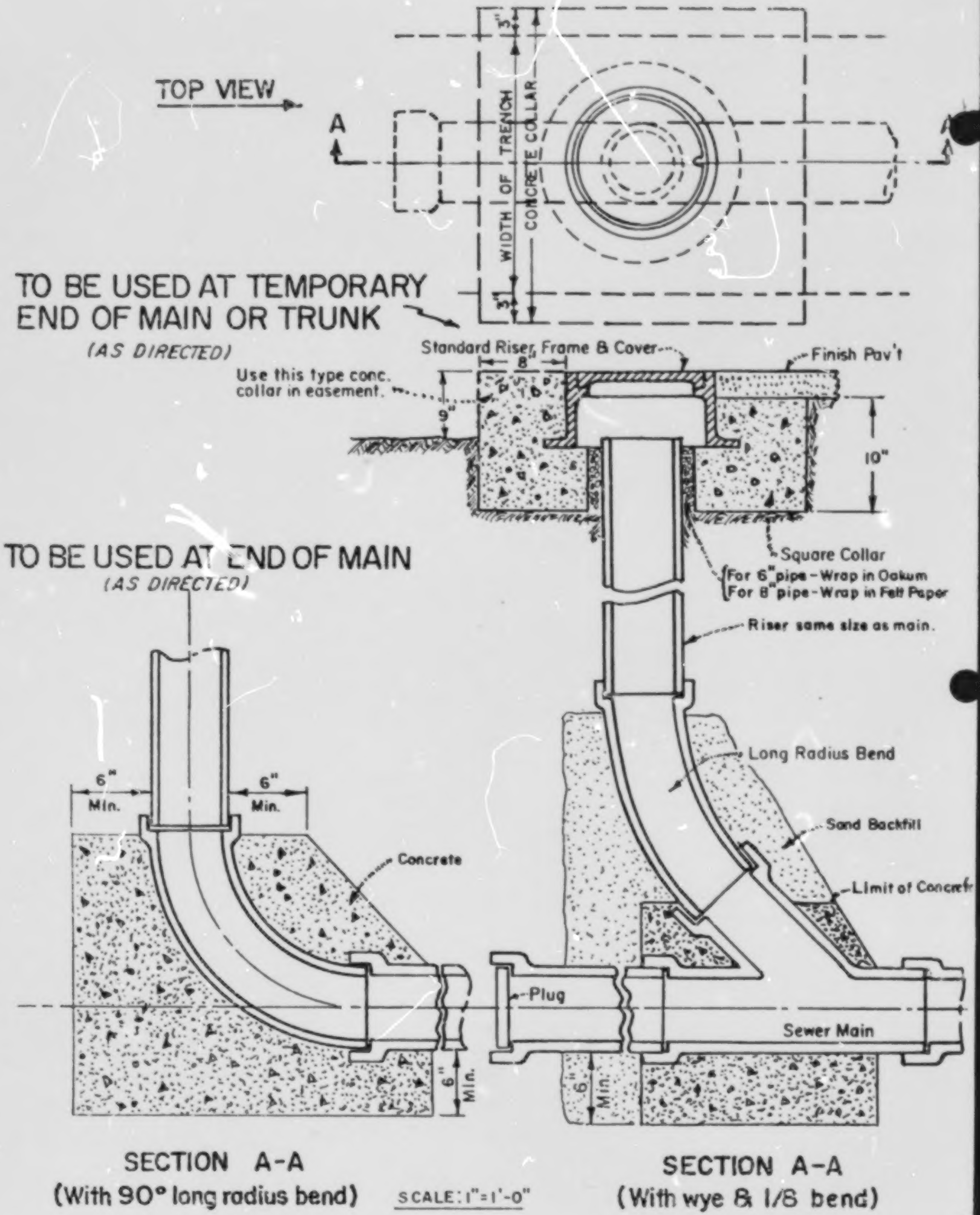

TOP VIEW
A
WIDTH OF TRENCH
CONCRETE COLLAR
3"
3"
TO BE USED AT TEMPORARY END OF MAIN OR TRUNK
(AS DIRECTED)
Standard Riser Frame & Cover
Finish Pav't
8"
Use this type conc. collar in easement.
9"
10"
Square Collar
For 6" pipe - Wrap in Oakum
For 8" pipe - Wrap in Felt Paper
Riser same size as main.
TO BE USED AT END OF MAIN
(AS DIRECTED)
6" Min.
6" Min.
Concrete
Long Radius Bend
Sand Backfill
Limit of Concre
Plug
Sewer Main
6" Min.
6" Min.
SECTION A-A
(With 90° long radius bend)
SCALE: 1"=1'-0"
SECTION A-A
(With wye & 1/8 bend)

Fig. 3.17. Standard vertical riser

(Courtesy of County Sanitation District No. 4,
Santa Clara County, California)

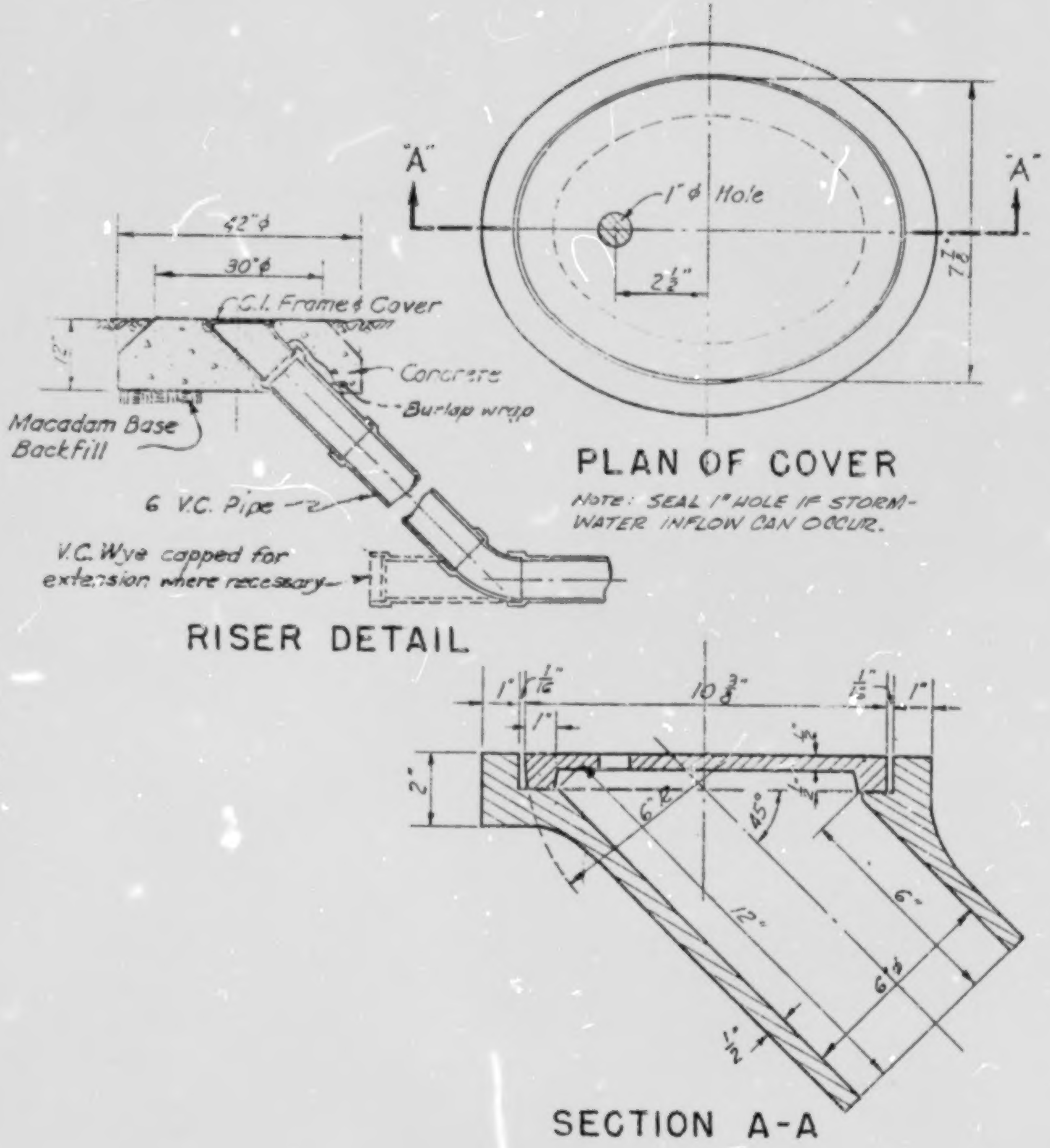

"A"
"A"
1" ϕ Hole
2 1/2"
7 7/8"
PLAN OF COVER
NOTE: SEAL 1" HOLE IF STORM-WATER INFLOW CAN OCCUR.
42"ϕ
30"ϕ
C.I. Frame & Cover
12"
Concrete
Burlap wrap
Macadam Base Backfill
6 V.C. Pipe
V.C. Wye capped for extension where necessary
RISER DETAIL
1"
1/16"
10 3/8"
1/16"
1"
1"
1/4"
2"
1/4"
6" R
45°
6"
12"
6"ϕ
1/2"
SECTION A-A

Fig. 3.18. Standard riser frame and cover
(Courtesy of County Sanitation District No. 4, Santa Clara County, California)

QUESTIONS

3.3A Name the different types of collection systems.

3.3B What types of wastewater does a combined sewer carry?

3.3C Where are cleanouts used?

3.3D What is used to minimize solid material settling in the bottom of inverted siphons?

3.4 DESIGN

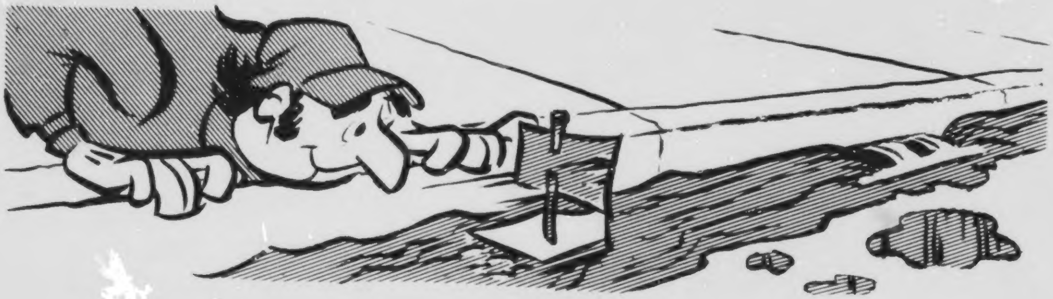
Sometimes wastewater collection systems are difficult to operate and maintain due to factors overlooked by designers. The more familiar collection system workers become with procedures and equipment used to operate and maintain collection systems, the better they can communicate with and assist designers. Experience in the field is very helpful when you have to explain to designers why changes should be made in plans and specifications to produce better collection systems. This section identifies factors design engineers consider and items you should consider when reviewing plans for proposed collection systems.

3.41 Scouring Velocities

Sewers are designed to convey wastewater at a velocity of at least two feet per second. When the velocity is below two feet per second, solids can settle out on the bottom of the pipe, reduce flow capacity, and eventually cause a stoppage. If the velocity is greater than 10 feet per second, solids could separate from the wastewater during low flows. At high velocities splashing occurs whenever the flowing water changes direction, which releases odors and accelerates corrosion of concrete structures. Flow velocities are estimated by designers, but the collection system worker's main concern is the actual velocity of the wastewater in the sewers you are maintaining.

3.42 Measuring Velocities in the Field

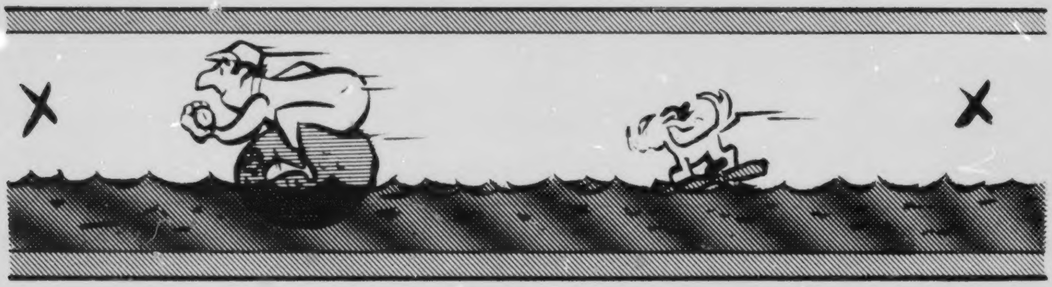
Velocities in sewers should be measured in the field to be sure ACTUAL velocities are high enough to prevent the deposition of solids. If roots or other obstructions get into a sewer, design velocities can be reduced and problems develop. Actual velocities in sewers can be measured by using dyes or floats. Realize that velocities vary during the day depending on the activities of the tributary population. A scouring velocity should be reached or exceeded during peak flows, but probably will not be reached during low flow periods.



Dyes. Dyes are very effective for estimating velocities. Put into the upstream manhole the smallest amount of dye that can be seen easily in the downstream manhole. Record the total travel time for dye to be first seen (t_1) and the total travel time until the dye finally disappears (t_2). The average time is $(1/2)(t_1 + t_2)$. The average velocity is calculated by dividing the distance by the average time.

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Average Time, sec}}$$

Floats. Floats are used to estimate velocities in existing sewers flowing partially full. A float could be a stick, an orange, or any other object that can be easily identified and that travels down the sewer at a velocity similar to the wastewater. Velocity is determined by recording the time the float takes to travel a known distance, such as the distance between manholes. Most surface floats such as sticks or oranges travel from 10 to 15 percent faster than the average velocity due to the velocity differences between the surface and bottom sections of the flowing water.



EXAMPLE

A stick travels the 400 feet between two manholes in three minutes and 20 seconds (200 seconds). Estimate the velocity in the sewer.

KNOWN	UNKNOWN
Distance, ft = 400 ft	Velocity, ft/sec
Time, sec = 200 sec	

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Time, sec}}$$

$$= \frac{400 \text{ ft}}{200 \text{ sec}}$$

$$= 2 \text{ ft/sec}$$

NOTE: The velocity of the stick (2 ft/sec) is 10 to 15 percent faster than the average velocity of the wastewater in the sewer.

$$\text{Average velocity, ft/sec} = 2 \text{ ft/sec} - 2 \text{ ft/sec } (0.10 \text{ to } 0.15)$$

$$= 2 \text{ ft/sec} - 0.2 \text{ to } 0.3 \text{ ft/sec}$$

$$= 1.7 \text{ to } 1.8 \text{ ft/sec}$$

3.43 Review of Plans and Specifications

Don't try to review all aspects of the plans and specifications for a new sewer or lift station. Spend your time looking at those factors that influence your job of maintaining the completed system.

3.431 Office Study

When you receive a set of plans and specifications to review, look them over and try to determine how the collection system is supposed to work. Be sure the sewers are large enough to handle expected flows and maintenance equipment. Make a list of items that are not clear or that you don't understand. Ask the designer to explain to you how the system was designed to work and try to have your questions and concerns answered.

3.432 Field Investigation

Now that you are familiar with the plans and specifications and how the collection system is supposed to work, you are prepared for your field investigation. This is the most important phase of your review. Carefully travel the entire length of every sewer and facility. Ask yourself the following questions as you investigate the entire system:

1. Is the route or alignment satisfactory?
2. Could there be a better route?
    a. Consider pipe diameters and depth of excavation.
    b. Think about maintenance equipment access.
3. Is there sufficient overhead clearance?
4. How could repairs be made in case of failures?
5. Can the system be easily and properly operated and maintained?
6. Will there be any industrial waste dischargers? If so, what will they discharge and will the discharge cause any problems? How can these problems be controlled?

QUESTIONS

3.4A Why should collection system workers review the plans and specifications for a sewer?

3.4B Why are velocities in a sewer important?

3.4C How can actual velocities in sewers be measured?

3.4D A dye travels the 300 feet between two manholes in an average time of seconds. Estimate the velocity in the sewer.

3.44 Materials for Sewers

Construction materials for sewers generally are selected for their resistance to deterioration by the wastewaters they convey, strength to withstand earth and surface loads, and their ability to minimize infiltration and exfiltration. Care must be taken in their selection since sewers are expected to have an economical life of at least 30 years and most are in service for a much longer period.

Pipe for construction of sanitary sewers is manufactured from several types of material producing either flexible or rigid pipe with specific characteristics that will perform satisfactorily in a particular situation. A flexible pipe will bend or bulge from its usual shape when subjected to a load without being adequately supported. However, it will not crack under most loads and will return nearly to its original shape when a load is removed. A rigid pipe will crack when the combination of a load on the pipe and its support causes a stress exceeding the strength of the pipe. It will not return to its original shape when the load is removed. Most of the commonly used sanitary sewer materials are described in the following subsections.

3.441 Acrylonitrile Butadiene Styrene Pipe (ABSP)

A flexible plastic pipe resistant to abrasion and virtually unaffected by water, inorganic salts, alkalies and acids usually found in wastewater. However, this pipe will be softened and eroded by wastewater containing petroleum products. Pipes are joined in the field using solvent cemented (welded) bell and spigot joints.

3.442 Asbestos Cement Pipe (ACP)

This pipe is rigid, resistant to abrasion, watertight and resistant to deterioration by most types of wastewaters. The pipe can be corroded by the acid formed from hydrogen sulfide gas, and the pipe should not be used where the release of hydrogen sulfide gas can occur. Joints are made of sleeve and rubber gasket couplings.

3.443 Cast and Ductile Iron Pipe (CIP and DIP)

The pipe is rigid and very resistant to crushing by surface and earth loads. Pipe is costly, but should be used for creek crossings and bridge crossings, or where trenches are shallow and under heavy traffic loads. Joints are either rubber-gasketed mechanical or push-on types.

3.444 Corrugated Metal Pipe (CMP)

A flexible pipe with bitumastic coating that is resistant to earth loadings. Special rubber gasketed corrugated bands with bolt tighteners are used with asphalt smooth-lined pipe.

3.445 Polyvinylchloride Pipe (PVCP)

This pipe is flexible and resistant to most chemicals found in wastewaters. Joints are made with a rubber gasket and a factory formed bell and spigot or a welded coupling joint can be used.

3.446 Reinforced and Nonreinforced Concrete Pipe (RCP and CP)

Concrete pipe is rigid and can be corroded by acids in wastewater or acid formed from hydrogen sulfide. Sometimes a coal tar epoxy compound coating or a plastic sheet lining can be used to line the pipe to retard the corrosive action. Tongue-and-groove joints with cement mortar filler are commonly used for storm sewer installations, and rubber-gasketed bell and spigot joints commonly are used for sanitary sewer installations.

3.447 Reinforced Plastic Mortar Pipe (RPMP) and Fiberglass Reinforced Pipe (FRP)

These pipes are flexible and resistant to corrosion by most chemicals found in wastewaters and acids formed in sewers; however, there is some evidence that these pipes are damaged by hydrogen sulfide. Joints are made with a rubber-gasketed bell and spigot.

3.448 Vitrified Clay Pipe (VCP)

The pipe is rigid and is resistant to internal and external attack from acids, alkalies, gases, solvents, and other materials that are carried in wastewater. Joints usually consist of bells and spigots with factory formed compression joints (liners of resilient-type plastic), or with rubber couplings held in place by stainless steel bands. Older pipes have mortar joints.

3.45 Pipe Joints

Pipe joints are a critical factor in every sewer. Poor joints can lead to problems caused by roots, infiltration and exfiltration. When reviewing the type of joint, consider the location of the sewer and the loads that will be placed on the joint (traffic, settling or other potential types of earth movement). Figure 3.19 summarizes the common types of joints and the types of pipes with which they are used.

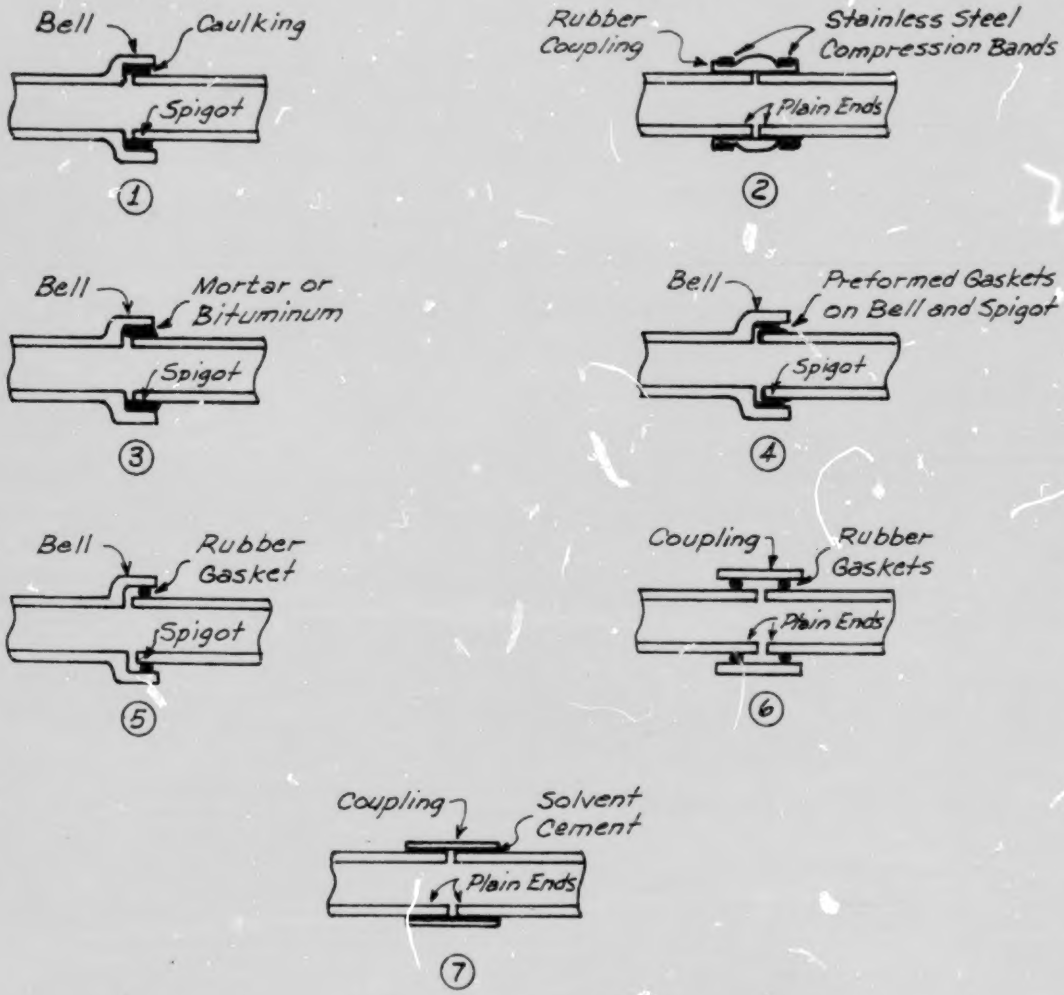
3.46 Manholes

The purpose of manholes is to provide access to sewers to clear stoppages and for maintenance and repair of sewers. When reviewing manholes, be sure the manhole can serve its intended purpose. To determine if a manhole is suitably located and properly designed, ask yourself the following questions when reviewing plans and specifications:

1. Where can vehicles be parked when workers and equipment require access to a manhole?

2. Is traffic a problem around or near the manhole?

3. Can the atmosphere in the manhole be tested safely for oxygen deficiency, explosive gases and toxic gases?


Bell
Caulking
Spigot
①
Rubber Coupling
Stainless Steel Compression Bands
Plain Ends
②
Bell
Mortar or Bituminum
Spigot
③
Bell
Preformed Gaskets on Bell and Spigot
Spigot
④
Bell
Rubber Gasket
Spigot
⑤
Coupling
Rubber Gaskets
Plain Ends
⑥
Coupling
Solvent Cement
Plain Ends
⑦

TYPE OF JOINTS

Joint No.	Joint Description	Joint Used with:							
		ABSD	ACP	CIP	PVCP	RCP	CP	RPMP	VCP
1	Caulked Bell & Spigot			✓					
2	Coupling for Plain End Pipe			✓					✓
3	Mortar/Bituminous Filled Bell & Spigot					✓	✓		✓
4	Polyvinyl Chloride/Polyurethane Preformed Gaskets in Bell & Spigot								✓
5	Rubber Gasketed Bell & Spigot			✓	✓	✓		✓	✓
6	Rubber Gasketed Coupling		✓						
7	Solvent Cemented Coupling	✓							

Fig. 3.19. Common types of joints for sewer and storm drain pipe

4. How can a worker reach the bottom of the manhole (with an aluminum ladder)?

5. If there are steps in the manhole wall for access, will they be damaged by corrosion and become unsafe (aluminum and stainless steel steps won't corrode, but the concrete surrounding them can corrode)?

6. Is the shelf in the bottom of the manhole properly sloped? If the shelf is too flat, the shelf will get dirty; and, if too steep, it can be a hazard to workers.

7. Are the channels properly shaped to provide smooth flow through the manhole?

8. Are the channels at least as large as the pipe so maintenance equipment and plugs can be fitted or inserted into the pipes?

9. Can the available sewer maintenance equipment be effective between the manholes or is the distance too great?

3.47 Operation and Maintenance

All of the topics discussed in this section on the review of the design of a wastewater collection system have been related to the operation and maintenance of the collection system. Now is the time to think about how you are actually going to operate and maintain the system. Will the procedures and equipment you plan to use be effective with this system?

3.471 Emergency Conditions

What kinds of emergency conditions (stoppages) could develop? Where are they most likely to occur? How can they be corrected? By determining the answers to these questions and deciding how you would solve these problems, you may be able to suggest to designers how they could make your job easier when an emergency condition develops.

3.472 Maintenance and Repair

Plan your maintenance program now. What equipment will you use (Chapter 5)? Can this equipment be used effectively with the new collection system? Is there enough room (big enough easement) for access and repairs when necessary? Again, by trying to visualize how you would solve these problems, you may be able to identify ways a design could be improved to your future benefit.

3.473 Sulfide Control

Hydrogen sulfide is a toxic, flammable and explosive gas which smells like rotten eggs and can be produced in sewers. Will hydrogen sulfide be a problem? If so, now is the time to have control measures installed. Chapter 5, Section 5.6, Hydrogen Sulfide Control, provides considerable detail on how to control hydrogen sulfide. When reviewing plans and specifications, try to visualize the wastewater flowing in the sewer. Wherever there is the possibility of splashing or turbulence (drops and bends), suggest to the designer other ways, routes, or channels for conveying the wastewater to minimize splashing and turbulence. Be sure there are provisions for adequate ventilation of the sewers because this is an effective means of controlling hydrogen sulfide.

3.48 Construction, Inspection and Testing

Designers must consider how the wastewater collection facilities they design will be constructed. Some facilities have been properly designed, but have not functioned as intended due to poor or improper construction materials and techniques. Good construction, inspection and testing procedures are very important in order to eliminate operation and maintenance problems that could develop from poor construction practices. Whenever problems (stoppages, failures or odors) develop in your collection system, try to identify the cause so it can be corrected now and in the future design of new systems. Did the problem start with the design, construction, or inspection of the facility; or was it caused by a waste discharger, by aging of the system, or by your maintenance and repair program? Whatever the cause, identify it and try to correct it.

The Supplement of this chapter provides details regarding the construction, inspection and testing of wastewater collection systems. Knowledge of this material will help you communicate with design engineers and also help you identify the causes of problems in your collection system. If your job today is not directly related to construction or construction inspection and testing, you may wish to skip the Supplement at this time, work the objective test, and go on to Chapter 4, Inspecting and Testing Collection Systems.

QUESTIONS

3.4F How are construction materials for sewers selected?

3.4G How can corrosion of concrete pipe be retarded?

3.4H What is the purpose of manholes?

3.4I When reviewing plans and specifications, what major operation and maintenance factors should be considered?

DISCUSSION AND REVIEW QUESTIONS

Chapter 3. Wastewater Collection Systems

Answer these discussion and review questions before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. How can wastewater collection system workers (you) help engineers design better systems?
2. The wastewater flow from an average home is about __________ gallons per person per day. What factors might cause this value to be different in your community?
3. Sketch a wastewater collection system showing the locations of building sewers, lateral sewers, main sewers and trunk sewers. Also show locations of cleanouts and manholes.
4. How does the flow in a combined sewer differ from the flow in a sanitary sewer?
5. How does a manhole differ from a vertical riser?
6. When is a wastewater pump used in a collection system?
7. How would you measure the flow velocity in a sewer?
8. Why should collection system workers review plans and specifications?
9. How would you review the plans and specifications for a new intercepting sewer?

SUGGESTED ANSWERS

CHAPTER 3. WASTEWATER COLLECTION SYSTEMS

3.1A Persons working on the operation and maintenance of wastewater collection systems should know something about how engineers design the system so they can:

1. Discuss with engineers the design, construction and inspection of the collection system.

2. Determine the correct action to take when the system fails to operate properly.

3.1B The purposes of a wastewater collection system are to accept, at the point of origin, water and water-carried wastes and to convey them in essentially unaltered condition to wastewater treatment plants.

3.2A Sources of wastewater in a collection system

1. Homes
2. Businesses
3. Industry
4. Inflow/infiltration

3.2B

1. Maximum daily flow = 2 x average daily flow
2. Maximum hourly flow = 3 x average daily flow
3. Minimum daily flow = 2/3 x average daily flow
4. Minimum hourly flow = 1/3 x average daily flow

3.2C Knowing the flow fluctuations in a collection system can be helpful in planning cleaning operations or repair work that should be conducted during high flows or low flows.

3.3A The different types of collection systems include:

1. Sanitary collection system
    a. Building sewers
    b. Lateral and branch sewers
    c. Main sewers
    d. Trunk sewers
    e. Interceptor sewers

2. Storm water collection system

3. Combined collection system

3.3B A combined sewer carries wastewater from residences, industries, and businesses and storm water (inflow/infiltration).

3.3C Cleanouts generally are used where the building plumbing connects to the building sewer and where the building sewer crosses the property line.

3.3D The settling of solids material in the bottom of inverted siphons is minimized by flow velocities that are sufficient to keep most solids in suspension.

3.4A Collection system workers should review plans and specifications for a sewer because often they can make suggestions on how the sewer could be designed so it would be easier to operate and maintain and do a more effective job.

3.4B Velocities are important for two reasons in sewers. A minimum velocity of two feet per second is critical to prevent solids from settling out and thus reducing capacity and possibly eventually causing a stoppage. High velocities can cause splashing which releases odors and accelerates corrosion of concrete structures.

3.4C Actual velocities in sewers can be measured by the use of dyes and floats.

3.4D

KNOWN			UNKNOWN
Distance, ft	=	300 ft	Velocity, ft/sec
Ave. Time, sec	=	100 sec	

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Average Time, sec}}$$

$$= \frac{300\text{ ft}}{100\text{ sec}}$$

$$= 3\text{ ft/sec}$$

3.4E The purpose of a field investigation along the route of a new sewer is to observe actual field conditions. This investigation provides the opportunity to visualize where the sewer will be located, identify potential problems, decide how they could be solved, and recommend how the design can be improved to reduce problems and make them easier to correct.

3.4F Construction materials for sewers generally are selected for their resistance to deterioration by the wastewaters they convey, strength to withstand earth and surface loads, and their ability to minimize infiltration and exfiltration.

3.4G Corrosion of concrete pipe can be retarded by the use of a coal tar epoxy compound coating or a plastic sheet lining.

3.4H The purpose of manholes is to provide access to sewers to clear stoppages and for maintenance and repair of sewers.

3.4I When reviewing plans and specifications, major operation and maintenance factors include:

1. Emergency conditions
2. Maintenance and repair
3. Sulfide control

OBJECTIVE TEST

CHAPTER 3. WASTEWATER COLLECTION SYSTEMS

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one answer to each question.

1. Wastewater collection systems usually consist of:
    1. Sewers
    2. Manholes
    3. Grit Chambers
    4. Stoppages
    5. Lift Stations
2. Collection system maintenance problems that should be considered during the design of the collection system include:
    1. Hazards from gases found in sewers
    2. Maintaining vehicles
    3. Cleaning sewers
    4. Clearing stoppages
    5. Clearing work orders with your supervisor
3. Wastewater carried by collection systems may come from
    1. Digester supernatant
    2. Homes
    3. Infiltration
    4. Inflow
    5. Exfiltration
4. Velocity of water flowing in a sewer may be estimated by
    1. Driving between manholes and reading speedometer in pickup truck.
    2. Measuring the time it takes to run between two manholes.
    3. Measuring the time it takes for dye to be carried by the wastewater between two manholes.
    4. Recording the time it takes for a floating object to travel between two manholes.
    5. Measuring the Manning's roughness coefficient for the sewer.

GO ON TO NEXT PAGE

5. Sewer pipe materials that can be corroded by acids formed from gases found in sewers include:

   1. Vitrified Clay Pipe
   2. Polyvinychloride Pipe
   3. Asbestos Cement Pipe
   4. Reinforced Concrete Pipe
   5. Reinforced Plastic Mortar Pipe

6. The purpose of a wastewater collection system is to accept, at the point of origin, water and water-carried wastes and to convey them at an acceptable rate to wastewater treatment plants.

   1. True
   2. False

7. Wastewater collection systems are usually gravity flow systems with as few pumps and other moving parts as possible.

   1. True
   2. False

8. Knowing how wastewater flow fluctuates in a sewer is useful in planning when to

   1. Plug a sewer for repairs
   2. Start the canning season
   3. Remove grit and debris from a sewer using a bucket machine
   4. Schedule cleaning operations using high flows
   5. Time the travel of root growths

9. Wastewater collection system workers should have a basic knowledge of how sewers are designed so they can

   1. Replace designers
   2. Communicate with designers
   3. Review plans and specifications
   4. Recommend improvements in design that make operation and maintenance of collection systems more effective
   5. Draw plans for the construction of collection systems

10. A minimum scouring velocity of 2 feet per second is necesssary so

    1. Sewer pipes won't become eroded on the bottom
    2. Solids won't settle out on the bottom of a sewer
    3. Roots won't grow in sewers
    4. Flow velocities can be estimated between manholes
    5. Solids won't build up in a sewer and reduce flow capacity

GO ON TO NEXT PAGE

11. What questions should be asked and answered during a review of plans and specifications and a field investigation of a new intercepting sewer?

    1. Is the route or alignment satisfactory?
    2. Are easements large enough?
    3. Is there sufficient overhead clearance?
    4. How could repairs be made in case of failures?
    5. Can the system be easily and properly operated and maintained?

12. When reviewing the plans and specifications of a new sewer, what items should be considered?

    1. How to clear stoppages
    2. How to handle flows when lift station pumps fail
    3. How to clean the sewer
    4. How to control hydrogen sulfide
    5. How to control odors

SUPPLEMENT

CHAPTER 3. WASTEWATER COLLECTION SYSTEMS

3.5 Construction
3.6 Sewer Construction Inspection
3.7 Testing of Pipes
3.8 Additional Reading

OBJECTIVES

CHAPTER 3. WASTEWATER COLLECTION SYSTEMS

After completion of Chapter 3 you should be able to do the following:

1. Explain proper and safe use of excavation equipment and shoring techniques.
2. Determine and check pipeline grade.
3. Inspect a sewer under construction for proper:
    a. Bedding materials and construction.
    b. Pipe laying procedures.
    c. Backfilling and compaction.
4. Describe the need for and duties of a wastewater collection system construction inspector.
5. Contact utility agencies with underground facilities near a construction or repair project before excavation starts.
6. Test ability of a wastewater collection system to withstand inflow/infiltration.
7. Keep accurate construction records and prepare necessary reports.

SUPPLEMENT

CHAPTER 3. WASTEWATER COLLECTION SYSTEMS
(Construction, Inspection and Testing)

3.5 CONSTRUCTION

3.51 Excavation and Shoring

Most sanitary and storm sewers are constructed within excavated trenches. Uncommon exceptions are sewers where construction must be made in tunnels, where surface conditions do not allow open excavation or the sewer is too deep for trenching equipment, and where sewers are constructed above ground for the purpose of spanning extensive watercourses where the use of inverted siphons is not practical. The following sections will outline the more important aspects of excavation for sewer construction and the shoring of these excavations to eliminate damage to adjacent property and to provide a safe work area during construction.

3.511 Excavation Equipment

The type of equipment to be used for excavating trenches for construction of sewers will be determined to a great extent by the size and depth of the sewer, type of material to be excavated, and the ground surface conditions. The more common types of excavation equipment and the conditions leading to their use are described in the following sections.

Trenching Machines. Trenching machines, consisting of steel buckets mounted on an endless chain or a wheel, with a conveyor belt to discharge excavated material to the side of the trench, are used at moderate depths in cohesive[11] types of soil where the vertical trench walls can be held with a standard type of shoring. In these situations trenching machines are quite productive. Trenching machines also can be used in sandy soils with a shield and solid sheeting of the trench walls. Because of high labor costs connected with the use of trenching machines, backhoes are commonly used in cohesive types of soils.

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[11] Cohesive (coe-HE-sive). Tending to stick together.

Backhoes. The most commonly used types of equipment for trench excavations are backhoes. They are manufactured in many sizes with varying depth capabilities and bucket sizes. Backhoes have the ability to excavate trenches with either vertical or sloping sides and, with use of a cable sling, can be used to lower large diameter sewer pipe into a trench, thus eliminating the need for a separate piece of equipment. A backhoe has the greatest ability to excavate through rocky and non-cohesive types of materials. Small, rubber-tired backhoes are quite mobile and are often used for small and restricted excavations.

Clamshells and Draglines. Clamshell and dragline buckets can be installed on most cranes. Clamshells are seldom used as the primary means of trench excavation due to their low productivity. However, this type of equipment is used when vertical lifts of excavated material in tight quarters are required, such as between shoring and at the headworks of sewer tunnels. Draglines, on the other hand, are most productive in open areas where the bucket may be cast into a wide sloping trench and the excavated material dropped to the side.

Special Equipment. Special equipment including air compressors, hydraulic splitters, jackhammers, and dynamite are sometimes needed to assist the previously discussed type of excavation equipment when large or solid rocks must be removed from the trench. Blasting of rocks is a hazardous operation requiring the services of specialists.

When high ground water levels are encountered during trench excavation, the water can be removed from the excavation by use of sump pumps or by use of a system of well points,[12] a header pipe and a central pump. The number and spacing of well point connections to the header pipe are dependent upon the ability of water to flow through the soil and the amount of water to be removed. Three-foot intervals are used with a six-inch diameter header pipe and two-foot intervals with an eight-inch diameter header pipe. Whenever ground water is controlled by lowering the water table, subsidence (dropping) of the ground in the nearby area may occur and cause damage to structures. After work is completed, try to allow the ground water level to return to its original level at the same rate it was lowered. This type of dewatering often tends to reduce the hazards of excavation in unsuitable soils.

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[12] Well point. A perforated metal tube or screen attached to a jetting or driving head end, designed to permit the passage of water. A well point is jetted or driven into place.

Front end loaders are used to load excess excavated material into dump trucks for hauling away from the job site.

3.512 Location of Utilities

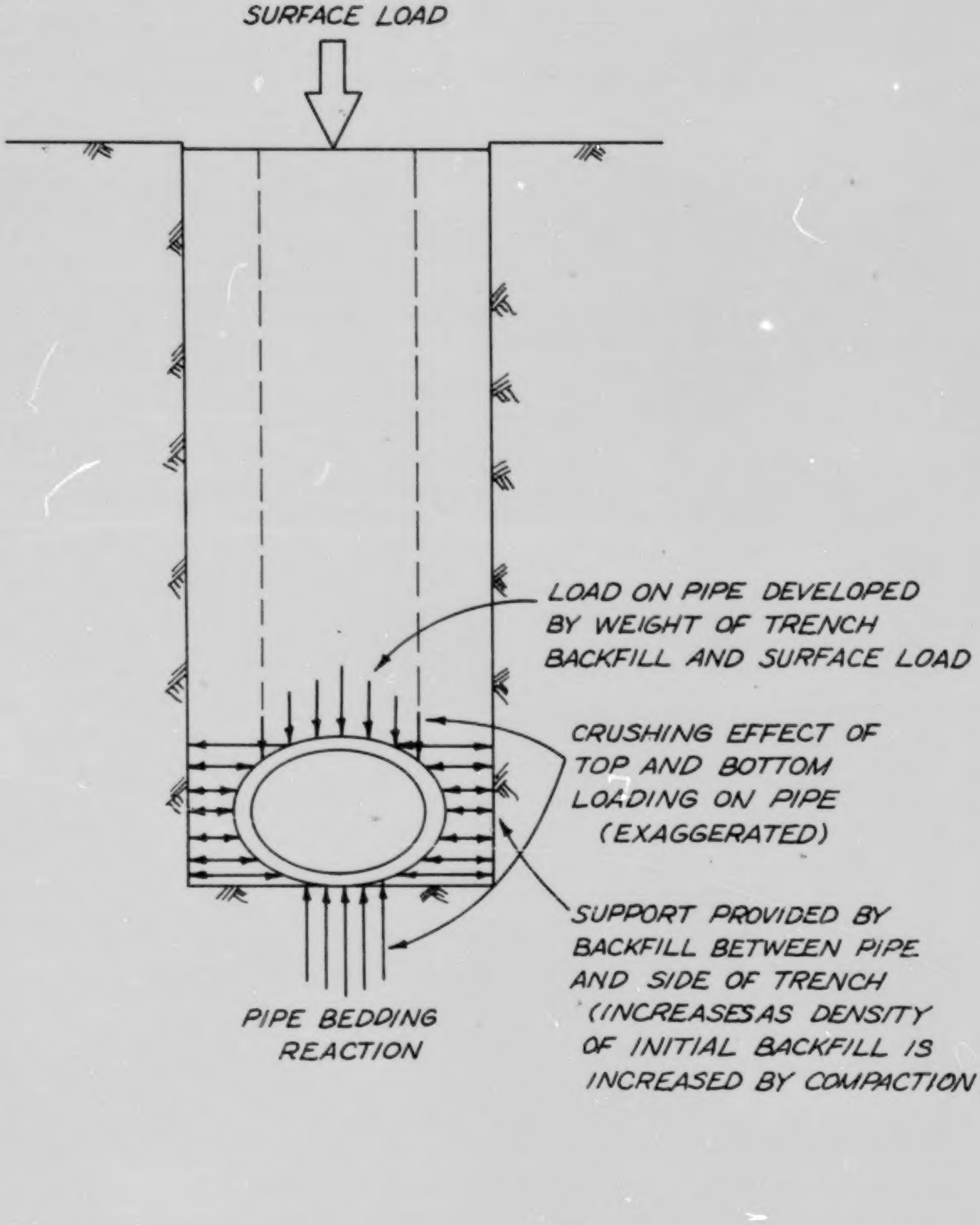
Most wastewater collection systems will be constructed in existing streets adjacent to and under existing underground utilities. Even though most construction plans will attempt to show the location of existing utilities, the information is generally based on utility companies' records and subject to inaccuracies.

All utility companies will provide a representative (locator) to find buried lines upon request. If an agency damages a buried utility line identified on the construction plans, the agency is liable for the damage and the cost of damages can be considerable. For instance, if a transcontinental phone cable is broken, the damages could cost $100,000 per minute of outage. If a utility company locator is requested and states that the agency is clear to dig and a utility line is broken, the agency is not liable for damages because the locator represents the utility agency. Having the locator on the job site before the agency starts digging can save time and money.

The State of New York has adopted regulations relating to "Construction, Excavation and Demolition Operations At or Near Underground Facilities" in order to assure safety and to prevent damage to public or private property. Also many localities have one telephone number that can be called for information on the location of underground utilities.

3.513 Effect of Trench Depth and Width on Sewer Pipe

The depth and width of a trench, backfill material and method of compaction determine the load placed on the sewer pipe, (Figure 3.20). The amount of support provided.the sewer pipe by the sides of the trench diminishes as the width of the trench increases. The width of a sewer trench (controlled by the diameter of the pipe, clearance for pipe laying and the excavation procedures) should be kept to a minimum.


SURFACE LOAD
LOAD ON PIPE DEVELOPED BY WEIGHT OF TRENCH BACKFILL AND SURFACE LOAD
CRUSHING EFFECT OF TOP AND BOTTOM LOADING ON PIPE (EXAGGERATED)
SUPPORT PROVIDED BY BACKFILL BETWEEN PIPE AND SIDE OF TRENCH (INCREASESAS DENSITY OF INITIAL BACKFILL IS INCREASED BY COMPACTION)
PIPE BEDDING REACTION

132

Fig. 3.20. Loading on pipe

Information on how to calculate the earth loads on sewer pipes can be found in Chapter 9 of the Design and Construction of Sanitary and Storm Sewers published by the Water Pollution Control Federation, 2626 Pennsylvania Avenue, N.W., Washington, D. C. 20037. Also, most sewer pipe manufacturers will furnish tables showing the loads developed on pipe under different conditions (trench depth, width and weight of soil) and the class of pipe needed to support these loads.

3.514 Trench Shoring

CAUTION

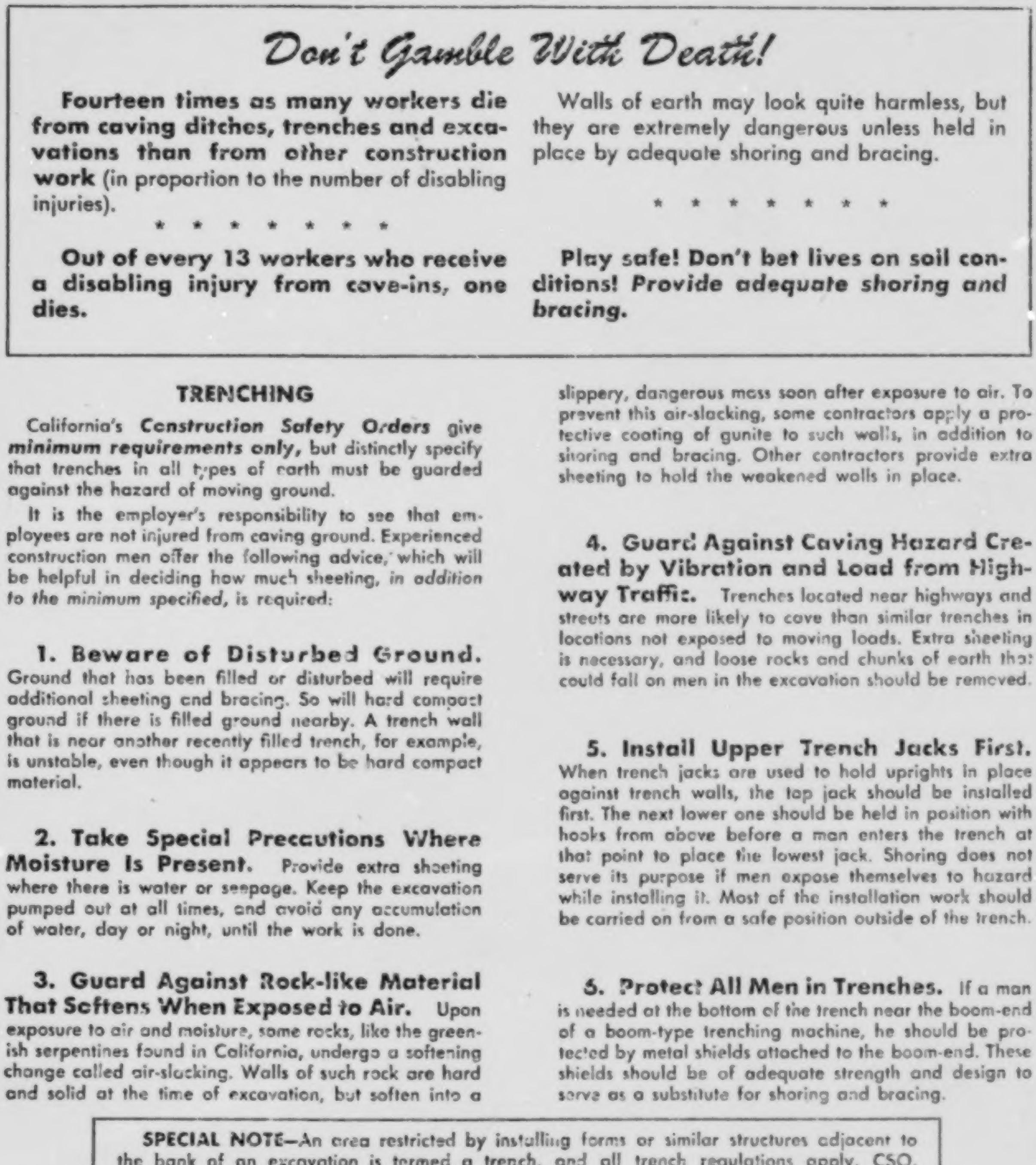
HAZARDOUS TRENCHING PROCEDURES ARE A PRIME CAUSE OF **DEATH** AND **INJURY**. A NATION-WIDE SURVEY CONDUCTED BY THE U.S. DEPARTMENT OF LABOR REVEALED THAT OVER 100 DEATHS IN 1972 WERE ATTRIBUTABLE TO CONSTRUCTION CAVE-INS. IN THE PERIOD 1963-1971 THE LABORERS INTERNATIONAL UNION REPORTED 187 OF ITS MEMBERS WERE KILLED IN CAVE-INS OF TRENCHES AND EXCAVATIONS.

NOTICE

AS A RESULT OF THIS HIGH INCIDENCE OF DEATH AND INJURY FROM TRENCH AND EXCAVATION CAVE-INS, THE FEDERAL OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA) ESTABLISHES REGULATIONS FOR THE PROTECTION OF WORKERS IN TRENCHES AND EXCAVATIONS. UNDER THIS ACT, EACH STATE ALSO MUST ADOPT SIMILIAR REGULATIONS. COPIES OF THE FEDERAL REGULATIONS FOR EXCAVATING, TRENCHING AND SHORING ARE CONTAINED IN "CODE OF FEDERAL REGULATIONS", TITLE 29 - LABOR, SUBPART P - EXCAVATIONS, TRENCHING AND SHORING, PARAGRAPH 1926.62, PAGES 854-859. OBTAINABLE FROM THE SUPT. OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C.

For example, State of California regulations on excavation, trenches, and shoring are set forth in Article 6 of the "Construction Safety Orders" established and administered by the Division of Industrial Safety, 455 Golden Gate Avenue, San Francisco, California 94102. For local regulations, consult your state industrial safety officer or similar person.

Figures 3.21 through 3.23 are taken from Bulletin S-158 published by the State of California, Department of Industrial Relations, Division of Industrial Safey as an example of excavation shoring regulations. For additional information on shoring, see Chapter 6, Underground Repairs, Section 6.2, Shoring.



Don't Gamble With Death!

Fourteen times as many workers die from caving ditches, trenches and excavations than from other construction work (in proportion to the number of disabling injuries).

* * * * * * * *

Out of every 13 workers who receive a disabling injury from cave-ins, one dies.

Walls of earth may look quite harmless, but they are extremely dangerous unless held in place by adequate shoring and bracing.

* * * * * * * *

Play safe! Don't bet lives on soil conditions! *Provide adequate shoring and bracing.*

TRENCHING

California's ***Construction Safety Orders*** give ***minimum requirements only,*** but distinctly specify that trenches in all types of earth must be guarded against the hazard of moving ground.

It is the employer's responsibility to see that employees are not injured from caving ground. Experienced construction men offer the following advice, which will be helpful in deciding how much sheeting, *in addition to the minimum specified,* is required:

1. Beware of Disturbed Ground. Ground that has been filled or disturbed will require additional sheeting and bracing. So will hard compact ground if there is filled ground nearby. A trench wall that is near another recently filled trench, for example, is unstable, even though it appears to be hard compact material.

2. Take Special Precautions Where Moisture Is Present. Provide extra sheeting where there is water or seepage. Keep the excavation pumped out at all times, and avoid any accumulation of water, day or night, until the work is done.

3. Guard Against Rock-like Material That Softens When Exposed to Air. Upon exposure to air and moisture, some rocks, like the greenish serpentines found in California, undergo a softening change called air-slacking. Walls of such rock are hard and solid at the time of excavation, but soften into a slippery, dangerous mass soon after exposure to air. To prevent this air-slacking, some contractors apply a protective coating of gunite to such walls, in addition to shoring and bracing. Other contractors provide extra sheeting to hold the weakened walls in place.

4. Guard Against Caving Hazard Created by Vibration and Load from Highway Traffic. Trenches located near highways and streets are more likely to cave than similar trenches in locations not exposed to moving loads. Extra sheeting is necessary, and loose rocks and chunks of earth that could fall on men in the excavation should be removed.

5. Install Upper Trench Jacks First. When trench jacks are used to hold uprights in place against trench walls, the top jack should be installed first. The next lower one should be held in position with hooks from above before a man enters the trench at that point to place the lowest jack. Shoring does not serve its purpose if men expose themselves to hazard while installing it. Most of the installation work should be carried on from a safe position outside of the trench.

6. Protect All Men in Trenches. If a man is needed at the bottom of the trench near the boom-end of a boom-type trenching machine, he should be protected by metal shields attached to the boom-end. These shields should be of adequate strength and design to serve as a substitute for shoring and bracing.

SPECIAL NOTE—An area restricted by installing forms or similar structures adjacent to the bank of an excavation is termed a trench, and all trench regulations apply. CSO, Sec. 1504 (11-E,O)

Fig. 3.21. Trenching
(State of California, Department of Industrial Relations, Division of Industrial Safety)

HARD COMPACT GROUND

Trenches 5 feet or more deep and over 8 feet long must be braced at intervals of 8 feet or less.

A strut brace is required for each 4-foot zone into which the trench depth can be divided, with at least two braces for each set of uprights.

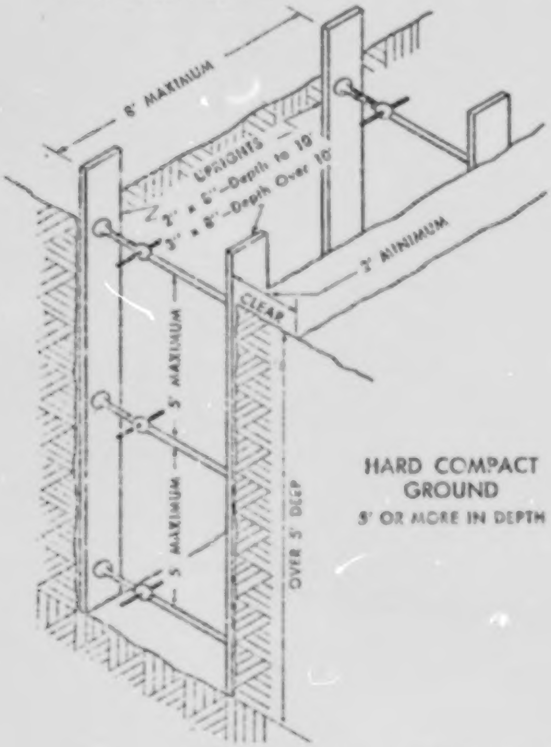
Steel screw-type trench braces must have a foot or base plate on each end of the pipe, placed horizontally and bearing firmly against uprights. Hydraulic metal jack units, properly maintained and of equivalent strength, also are acceptable.

Timber braces must be in good condition, free from imperfections affecting their strength, well cleated, and rigidly wedged.

Horizontal Strut Braces

Width of Trench Feet (Incl.)	Size of Wood Braces	Size of Pipe Braces
1– 3	4"x4"	1½" STD
3– 6	4"x6"	2" STD
6– 8	6"x6"	2" STD
8–10	6"x8"	3" STD
10–12	8"x8"	3" STD

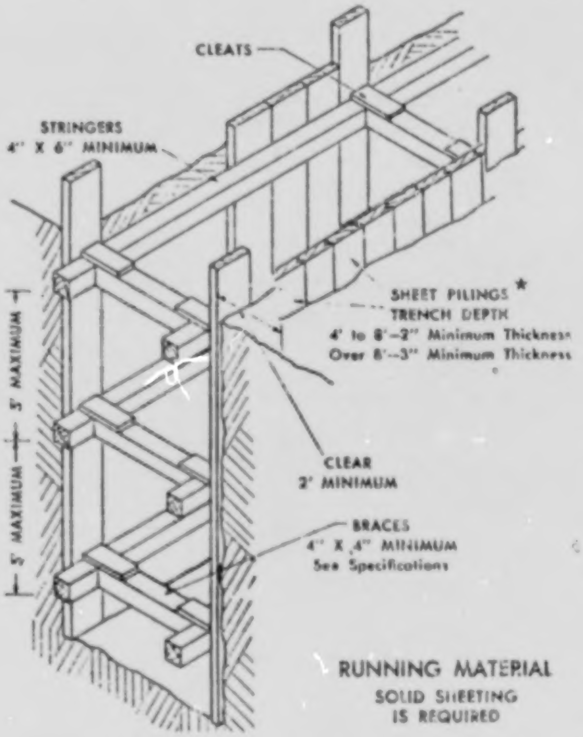
Trenches wider than 12 feet must have braces of correspondingly larger dimensions.


8' MAXIMUM
UPRIGHTS
2" x 6"—Depth to 10'
3" x 8"—Depth Over 10'
2' MINIMUM
CLEAR
5' MAXIMUM
5' MAXIMUM
5' MAXIMUM
OVER 5' DEEP
HARD COMPACT GROUND
5' OR MORE IN DEPTH

FILLED OR UNSTABLE GROUND

Sheeting must be provided, and must be sufficient to hold the material in place.

Longitudinal-stringer dimensions depend upon the strut and stringer spacing and upon the degree of instability encountered.


CLEATS
STRINGERS
4" X 6" MINIMUM
SHEET PILINGS *
TRENCH DEPTH
4' to 8'–2" Minimum Thickness
Over 8'–3" Minimum Thickness
5' MAXIMUM
5' MAXIMUM
CLEAR
2' MINIMUM
BRACES
4" X 4" MINIMUM
See Specifications
RUNNING MATERIAL
SOLID SHEETING
IS REQUIRED

Trench Shoring Specifications

SOIL TYPE	DEPTH	UPRIGHTS		BRACES		STRINGERS	
	Feet	Size Inches	Horizontal Spacing, Feet	Size Inches	Horizontal Spacing Feet	Size Inches	Vertical Spacing, Feet
Hard, Compact	5-10	2X6	8	4X4	5	Where indicated	
	Over 10	3X8	6	4X6	6	Where indicated	
Unstable	5-10	2X6	4	4X4	4	Where indicated	
	Over 10	3X8	Solid	4X6	6	4X6	4
Running	4-8	2X6	Solid	4X4	6	4X6	4
	Over 8	3X8	Solid	6X6	6	6X6	4

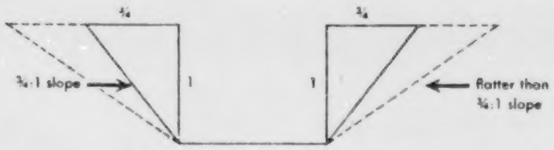
* Author's Note: Steel sheet piling is commonly used in place of timber piling.

Fig. 3.22. Shoring
(State of California, Department of Industrial Relations, Division of Industrial Safety)

ALTERNATE TRENCH PROTECTION

Sloping

Trench or excavation walls must be sloped no less than ¾ horizontal to 1 vertical as an alternate method to shoring. Soil instability may, however, require a flatter slope.



Protective Shields

Protective shields or welder's huts may be substituted for shoring systems to provide local protection for workmen in trenches. Approval of their design and construction shall be secured from the Division of Industrial Safety by the employer before use.

Design by Registered Engineer

A civil engineer, registered in California, may design and submit detailed data to the Division of Industrial Safety for alternate effective shoring systems. The design must include a soil evaluation study, a slope stability study, and an estimation of forces to be resisted, together with plans and specifications of the materials and methods to be used.

Upon review of the application and supporting data, the Division may accept the provisions of the alternate proposal or add such modifications as appear just and reasonable. See Plate C-24-a, b, Appendix, Construction Safety Orders, for engineering design alternate criteria.

ACCESS

In trenches five feet or more deep, ladders must extend at least 2½ feet above the top, unless a safer means of getting in and out of the trench is provided.

There must be a ladder within 50 feet of any worker in a trench.

PIPE INSTALLATION

Length or diameter of pipe being installed does not permit variance with shoring requirements. Shoring protection is required within at least 4 feet of any workman.

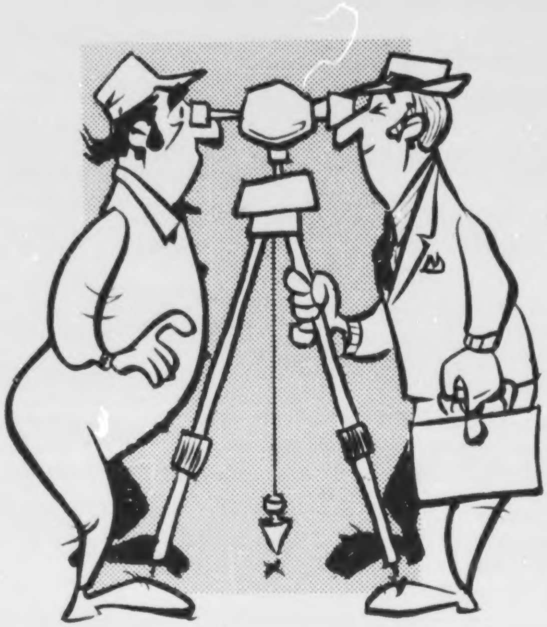
Fig. 3.23. Trench protection and access (State of California, Department of Industrial Relations, Division of Industrial Safety)

3.52 Line and Grade

The line and grade of a sanitary or storm sewer are based on field surveys to determine existing conditions to be met and the service to be provided by the sewers. This information is used to prepare a plan and profile of the sewer to be constructed. The plan and profile are used to establish the line and grade controls used for construction.

3.521 Field Surveys

Field surveys determine the location of the facilities to be served by the proposed sewer, the location of surface and underground obstructions, the elevation of the sewer to be extended, elevations of plumbing in existing buildings to be served, and underground utilities to be crossed. Figure 3.24 illustrates the field notes developed for construction of a sanitary sewer.

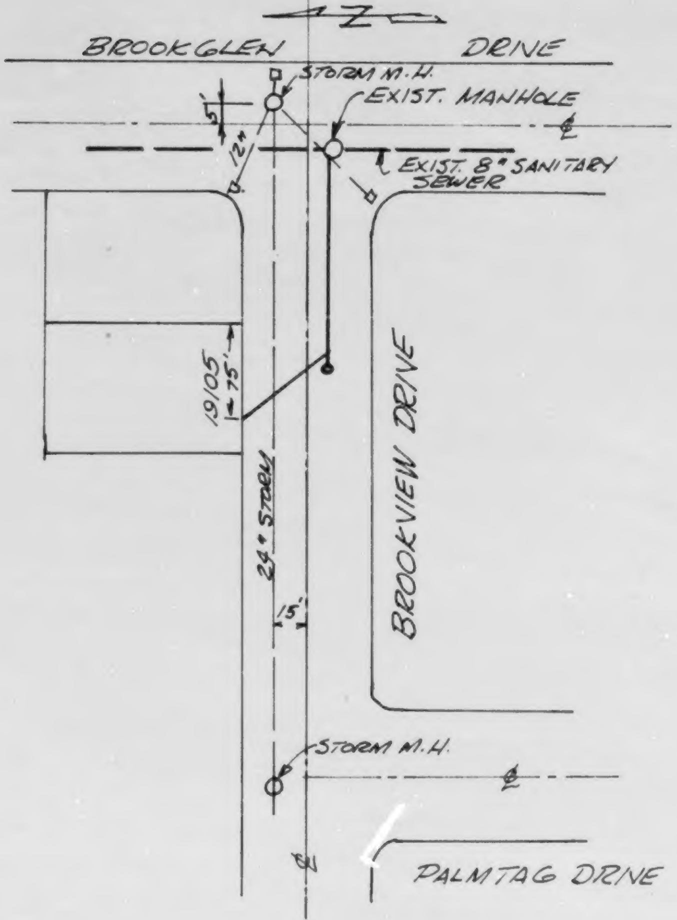


Borings of the soil at about 400-foot intervals should be made along and to the depth of the proposed sewer and the types and depths of soils found indicated on the construction plans.

6" LATERAL AND 4" BUILDING SEWER
EXTENSION TO 19105 BROOKVIEW DRIVE

6/28/73 DRY & WARM
L.T. ⌀
W.G. ⊼ ⌧

OBJ.	B.S.	H.I.	F.S.	ELEV.	B.M.
INV. 8"					263.47
	13.85	277.32			
SANITARY M.H. RIM			5.65	271.67	
0+00			5.69	271.63	
+50			5.57	271.75	
1+00			5.38	271.94	
1+19			5.31	272.01	
+50			5.20	272.12	
+75			5.06	272.26	
2+75			5.34	271.98	
3+05			5.43	271.89	
M.H. RIM			5.64	271.68	
0+00				271.63	
	5.41	277.04			
STORM M.H. RIM			5.62	271.42	
(DIP)				6.46	
INV.				264.96	
PALMTAG M.H. RIM			5.43	271.61	
(DIP)				4.56	
				267.05	


N
BROOKGLEN DRIVE
STORM M.H.
EXIST. MANHOLE
5'
12"
℄
EXIST. 8" SANITARY SEWER
19105
75'
24" STORM
15'
BROOKVIEW DRIVE
STORM M.H.
℄
PALMTAG DRIVE

NOTE: CONSTRUCTION CONTROLS SET 5' RIGHT OF SEWERLINE.

Fig. 3.24. Field notes

Traverse Surveys. Field surveys to determine the physical features influencing the horizontal location of sanitary and storm sewers and the designed alignment of the sewers are called traverse surveys and are done by surveyors or engineers.

Level Surveys. Field surveys to determine the elevation of existing features (such as a ground profile) or to establish the grade controls for a sanitary or storm sewer to be constructed are called level surveys.

The personnel and equipment used to make a level survey generally consist of the following:

1. An instrument man and an assistant.
2. A surveyor's level that will establish a level line of sight through a 360-degree angle by a horizontal cross-hair in a telescope.
3. A rod marked in 0.01 of a foot and about 7.5 feet long (extendable to 14 feet).
4. A hammer and stakes.

A level survey is made in the following manner (see Figure 3.25):

1. The instrument man sets the level at a convenient location (where back and fore sights can be made) and levels the instrument.
2. The assistant holds the rod plumb on a point of known elevation (a bench mark) and the telescope of the level is back sighted (BS) on the rod and the distance that the cross-hair is above the bench mark is read on the rod (5.65 feet in Figure 3.25).
3. The height of the instrument (HI) above the bench mark (BM) is determined by adding the BS distance to the bench mark elevation (HI = BM + BS = 263.47 + 5.65 + 8.20 = 277.32). The 8.20 is the measured distance from the invert elevation of 263.47 to the top of the manhole as shown in Figure 3.25.
4. The elevation of any other point is then determined by holding the rod plumb on the point. The level telescope is pointed at the rod (fore sighted) and the distance of the horizontal cross-hair above the point is read on the rod (5.38 feet at station 1+00 in Figure 3.25).

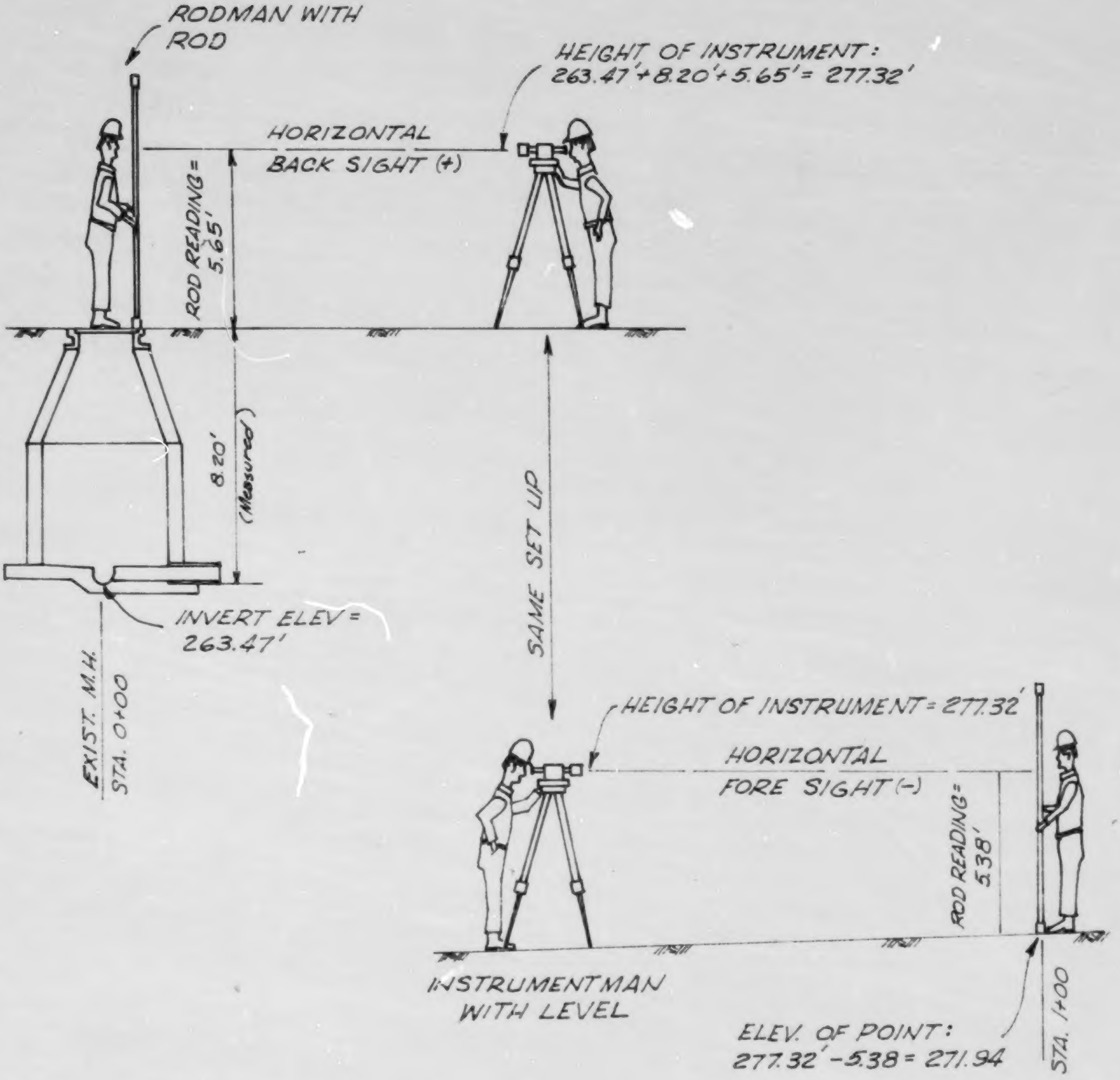

RODMAN WITH ROD
HEIGHT OF INSTRUMENT: 263.47'+8.20'+5.65'= 277.32'
HORIZONTAL
BACK SIGHT (+)
ROD READING= 5.65'
8.20' (Measured)
SAME SET UP
INVERT ELEV= 263.47'
EXIST. M.H.
STA. 0+00
HEIGHT OF INSTRUMENT= 277.32'
HORIZONTAL
FORE SIGHT (-)
ROD READING= 5.38'
INSTRUMENTMAN WITH LEVEL
ELEV. OF POINT: 277.32'-5.38= 271.94
STA. 1+00

Fig. 3.25. Level survey

5. The elevation of the point is then determined by subtracting the FS distance from the HI (EL. 1+00 = HI - FS = 277.32 - 5.38 = 271.94).

6. If the instrument man needs to move the level due to (1) an obstruction in his line of sight, (2) the FS point being above the HI, or (3) the FS distance being greater than the length of the rod, a secondary bench mark (turning point) is established and its elevation carefully determined. The level is moved to a new location and the HI determined by back sighting on the turning point. For example, in the level survey made to develop the field notes shown in Figure 3.24, the nail designating station 0+00 with a previously determined elevation of 271.63 was used as a turning point for the purpose of setting the level for observation of a storm sewer that had to be considered in design of the sanitary sewer. The height of the instrument was determined by making a backsight on a rod held on the turning point and adding the reading to the elevation of the point (HI = TP + BS = 271.63 + 5.41 = 277.04). The elevation of the storm sewer manhole rim was determined by holding a rod on the rim and subtracting the fore sight rod reading from the HI (EL. MH Rim = HI - FS = 277.04 - 5.62 = 271.42).

7. The invert elevation of the storm sewer at the manhole was determined by using the surveyor's rod to measure the distance from the rim to the invert and then subtracting this distance from the rim elevation (EL. Invert = EL. Rim - Dip = 271.42 - 6.46 = 264.96).

3.522 Plan and Profile

A civil engineer will use field notes and the factors previously described in Section 3.4 to design sanitary or storm sewers. The design is set forth in a construction plan, showing the location of the sewer and a profile, showing the grade the sewer is to follow. A typical sanitary sewer plan and profile developed from the field notes described in Section 3.521 are shown in Figure 3.26.

With the greater use of curved streets today and the development of sewer cleaning equipment that is more versatile, sewers are sometimes constructed along curved paths. The radius of a curved sewer will be determined by the radius of the street in which the sewer is being constructed, allowable deflection in the sewer pipe joints,

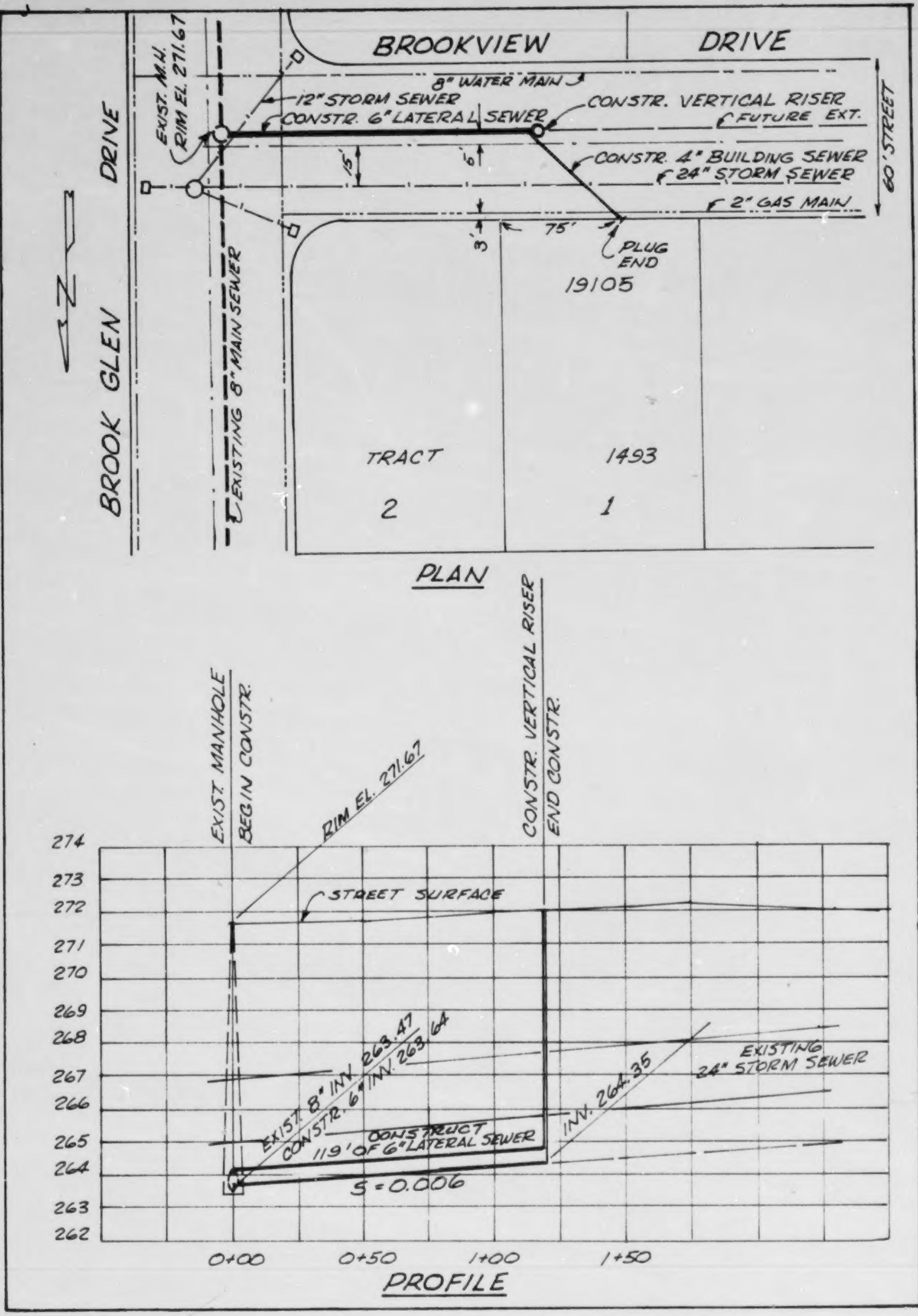

BROOKVIEW
DRIVE
8" WATER MAIN
12" STORM SEWER
CONSTR. 6" LATERAL SEWER
CONSTR. VERTICAL RISER
FUTURE EXT.
CONSTR. 4" BUILDING SEWER
24" STORM SEWER
2" GAS MAIN
60' STREET
EXIST. M.H. RIM EL. 271.67
15'
6'
3'
75'
PLUG END
19105
BROOK GLEN DRIVE
N
EXISTING 8" MAIN SEWER
TRACT
1493
2
1
PLAN
EXIST. MANHOLE
BEGIN CONSTR.
RIM EL. 271.67
CONSTR. VERTICAL RISER
END CONSTR.
STREET SURFACE
274
273
272
271
270
269
268
267
266
265
264
263
262
EXIST. 8" INV. 263.47
CONSTR. 6" INV. 263.64
CONSTRUCT 119' OF 6" LATERAL SEWER
S = 0.006
INV. 264.35
EXISTING 24" STORM SEWER
0+00
0+50
1+00
1+50
PROFILE

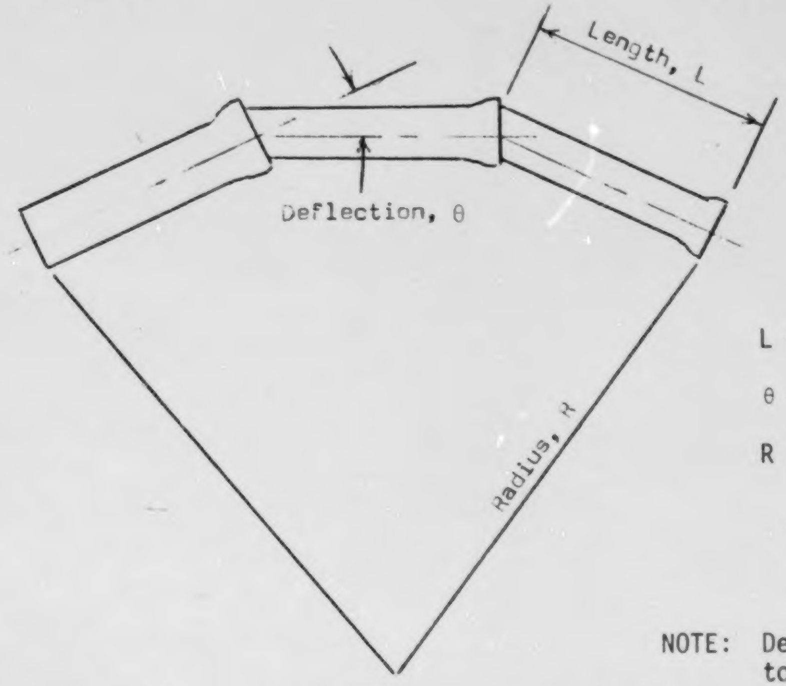
Fig. 3.26. Plan and profile

and of major importance, the effect of radius upon cleaning procedures. Some state and local regulatory agencies prohibit the use of curved sewers because of maintenance problems. For the efficient use of modern sewer cleaning equipment, the radius of curvature must be greater than 200 feet.

Most sewer pipe manufacturers will specify the maximum allowable deflection in a joint. Knowing this amount of deflection and the length of pipe between joints, the allowable radius of curvature for sewer pipe can be determined by the use of the following formula:

$$\text{Radius, ft} = \frac{360\ (\text{Length, ft})}{4\pi\ (\theta\text{, degrees})}$$

FOR EXAMPLE:



L = 5 feet

θ = 2 degrees

$$R = \frac{(360)\ (5\text{ ft})}{(4)(3.14)(2^{\circ})}$$

= 72 feet

NOTE: Deflection exaggerated to illustrate radius of curvature

3.523 Placement and Designation of Construction Controls

Surveyors, using a sewer plan and profile, set construction controls usually at 50-foot intervals in the form of stakes driven into the ground or nails and washers (shiners) driven into pavement at a designated off-set from the sewer center line as shown in Figure 3.27. The precise elevation of the control stake or nail is determined by its relation to a previously determined control elevation called a "bench mark". Figure 3.24 illustrates the field notes of a survey to place and determine the elevation of the controls for the sanitary sewer set forth in the plan and profile illustrated by Figure 3.26.

Note that the construction controls have been set on a 5-foot right off-set from the sewer center line as you face upstream with respect to the wastewater flow. The size of the sewer and method of trench excavation will determine the best side and off-set distance for the controls. Also note that the distance of the construction control from the starting point along the sewer is expressed in terms of 100-foot stations and usually to one hundredths of a foot. For example, a manhole 425.26 feet from the beginning of construction would be located at station (sta) 4+25.26. Construction controls usually are placed at 50-foot intervals and would be designated 0+00, 0+50, 1+00, 1+50 and so on.

Surveyors mark the off-set of the construction controls from the sewer center line and the amount of cut in feet from the top of the control point to the invert of the sewer on a grade stake or on the pavement exactly opposite the control. In Figure 3.27 the markings on the guard stake are as follows:

⑤ - Offset 5 feet

0+00 - Station 0+00 or distance from starting point

C - Cut

$7^{\underline{99}}$ - Cut 7.99 feet or depth of trench below hub

The cut from the top of the construction control to the invert of the sewer is calculated by knowing the given elevation of the beginning point of the sewer to be constructed, the sewer slope (grade), the distance from the beginning point to the construction control, and the elevation of the control. Figure 3.28 shows the cut sheet calculations for the sanitary sewer illustrated by Figure 3.26 using the survey notes in Figure 3.24.

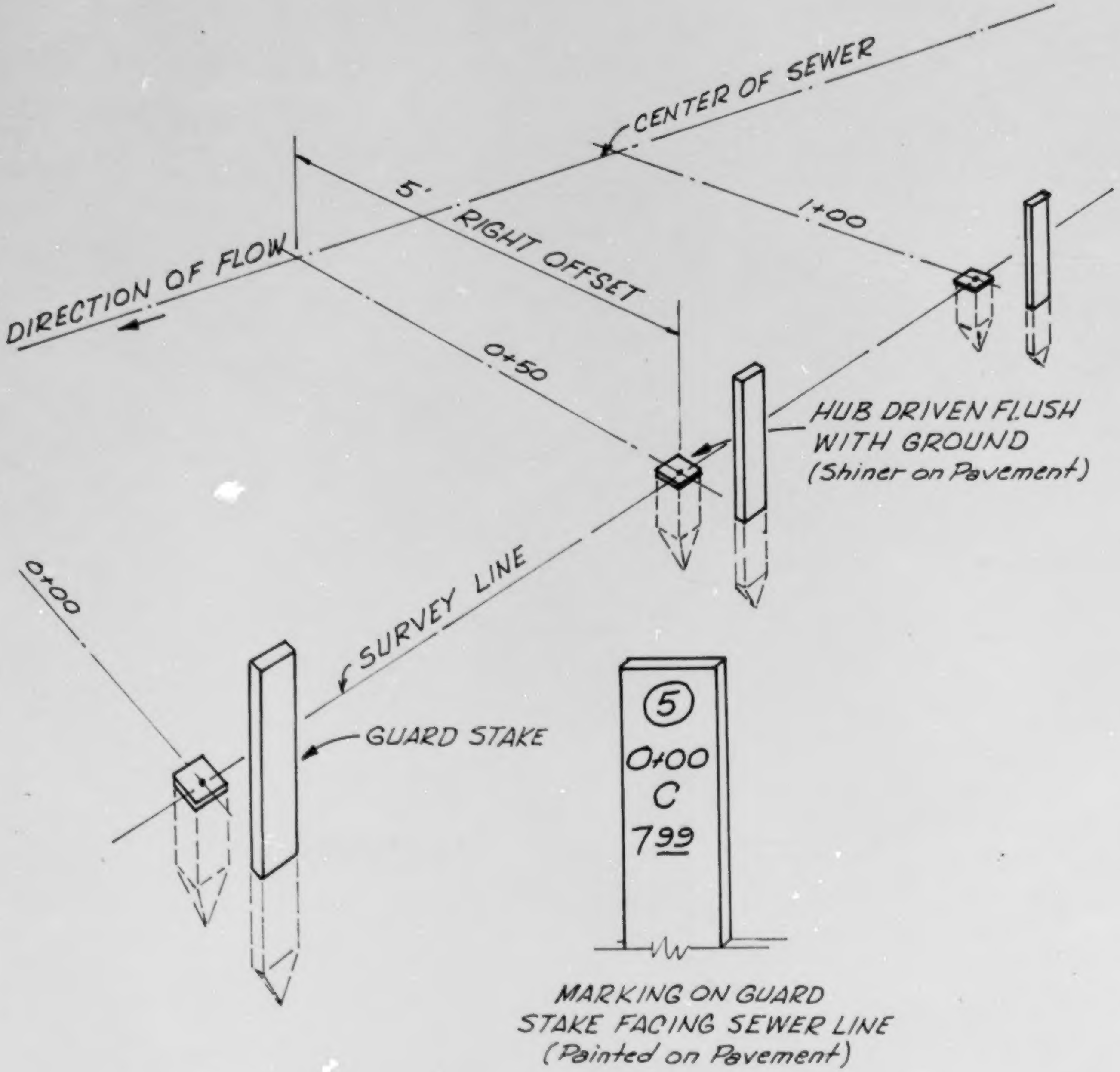

CENTER OF SEWER
5'
RIGHT OFFSET
1+00
DIRECTION OF FLOW
0+50
HUB DRIVEN FLUSH
WITH GROUND
(Shiner on Pavement)
0+00
SURVEY LINE
GUARD STAKE
5
0+00
C
7 99
MARKING ON GUARD
STAKE FACING SEWER LINE
(Painted on Pavement)

Fig. 3.27. Controls for sewer construction

PROJECT 6" LATERAL SEWER EXTENSION JOB NO. ______

LOCATION BROOKVIEW DRIVE DATE 7/25/63

Station	Elevation of Point	Elevation of Invert	Cut to Invert	Remarks
5' RIGHT 0+00	271.63	263.64	7.99	EXIST. MANHOLE AT BROOK GLEN DRIVE
0+50	271.75	SLOPE 0.006 263.94	7.81	
1+00	271.94	264.24	7.70	
1+19	272.01	264.35	7.66	CONSTR. VERTICAL RISER

Fig. 3.28. Sanitary sewer cut sheet

To prepare a Sanitary Sewer Cut Sheet, as illustrated by Figure 3.28, the following steps are taken:

In the field, Surveyor:

1. Sets control hub or shiner 5 feet to right of line and records Station.
2. Determines elevation of established hub or shiner, Elevation of Point.
3. Records Elevation of Invert for Station 0+00 "Exist. manhole at Brookglen Drive" as 263.64.

In the office or in the field:

4. Determine slope of line to be constructed from plan or profile, slope = 0.006 ft/ft.
5. Calculate Elevation of Invert for each Station by multiplying Station (a) times slope (b) and adding result (c) to elevation of existing manhole invert (d) to obtain Elevation of Invert (e).

Station (a)	x	Slope (b)	=	Rise (c)	+	Exist. (d)	=	Invert (e)
50		0.006		0.30		263.64		263.94
100		0.006		0.60		263.64		264.24
119		0.006		0.71		263.64		264.35

6. To calculate Cut to Invert, take Elevation of Control (a) and subtract Elevation of Invert (b), to obtain Cut to Invert (c).

Station	Elevation of Control (a)	-	Elevation of Invert (b)	=	Cut to Invert (c)
0+00	271.63		263.64		7.99
0+50	271.75		263.94		7.81
1+00	271.94		264.24		7.70
1+19	272.01		264.35		7.66

By following this step-by-step procedure, you can learn to calculate cuts to inverts and others can easily check your work and show you where any errors were made in calculations.

3.524 Use of Construction Controls

The line and grade controls for the sewer are used first to determine the location and depth of the sewer trench and second for laying the sewer pipe to the proper line and grade.

Trench Excavation. The project foreman will place steel rods immediately adjacent to the control point (stake or nail) and will mark on each rod an even number of feet of cut to the sewer invert. For example, if the cut from a control point to the invert is 6.73 feet, he would mark an 8.00-foot cut by measuring 1.27 feet up from the control point to a point on the steel rod. A grade string line then will be stretched between three consecutive control points on the steel rods in order to detect any errors either in the control survey or setting of the string line. Figure 3.29 illustrates setting of the grade string line and the 3-point method of detecting errors.

The excavating equipment operator uses the grade string line to control his depth of cut. In most instances sewer trenches are excavated a pre-determined distance below the invert of the sewer to provide for the thickness of the pipe's wall and for imported bedding under the pipe. For instance, if the sewer pipe has a wall thickness of 0.10-foot and a 0.25-foot thick bedding, an 8-foot cut from the grade line to the pipe invert would become an 8.35-foot cut to the bottom of the trench.

A trenching machine, as described in Section 3.511, has an indicator that follows along the string line when the operator has the excavating bucket line on line and grade. When backhoes, clamshells, or draglines are used to excavate a trench, the equipment operator's assistant will check the line and grade by the use of a grade pole illustrated in Figure 3.30.

Pipe Laying. A common practice is to use the same grade string line used for trench excavation control for pipe laying control. A grade pole, as described in the previous section under trench excavation, is used to transfer the grade line from the ground surface to a string line in the bottom of the trench set at an arbitrary distance above the invert of the sewer pipe as illustrated in Figure 3.31. The person installing the pipe then measures down the

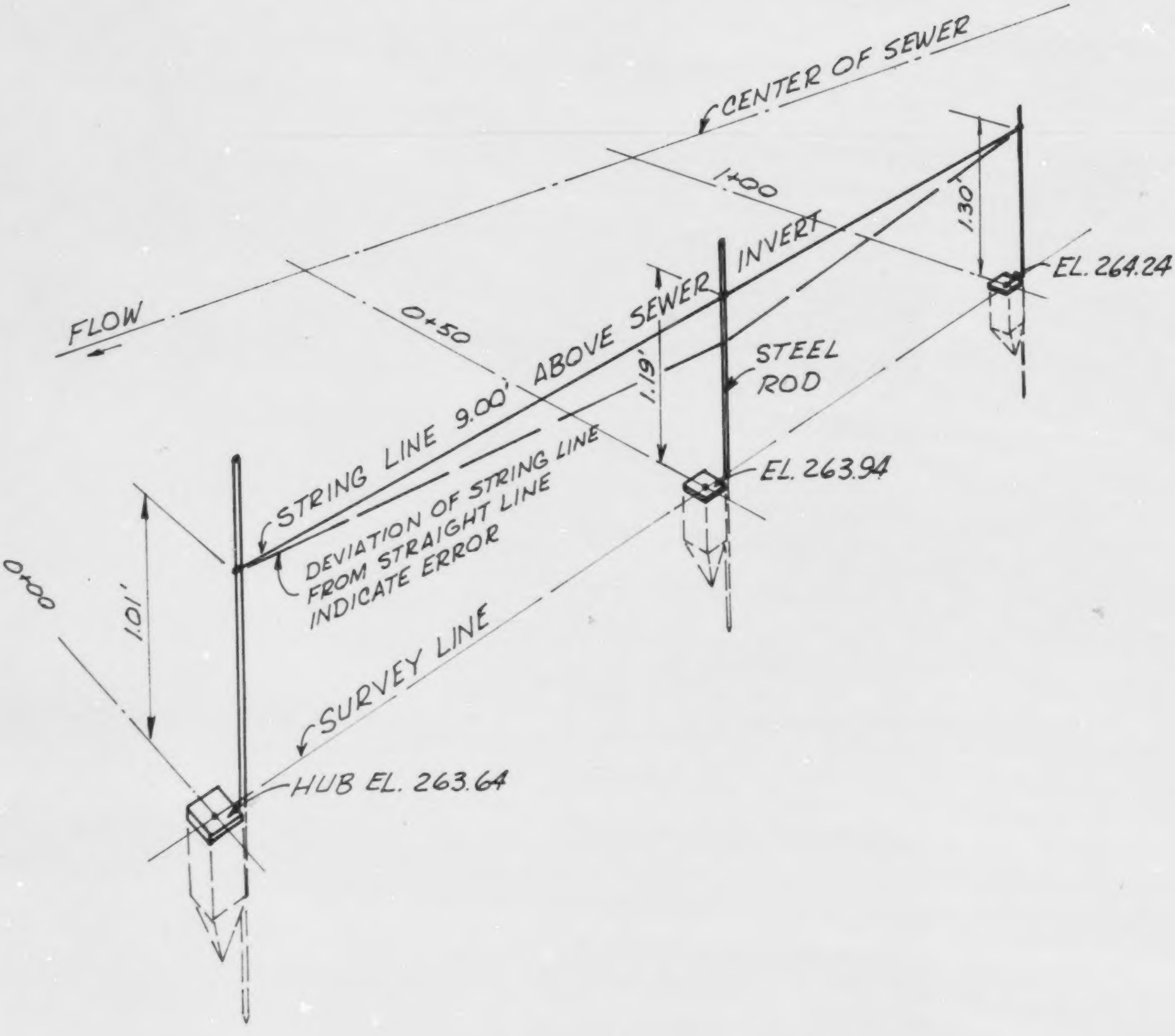

CENTER OF SEWER
1+00
1.30'
EL. 264.24
INVERT
FLOW
0+50
STRING LINE 9.00' ABOVE SEWER
1.19'
STEEL ROD
EL. 263.94
DEVIATION OF STRING LINE FROM STRAIGHT LINE INDICATE ERROR
0+00
1.01'
SURVEY LINE
HUB EL. 263.64

Fig. 3.29. Excavation string line

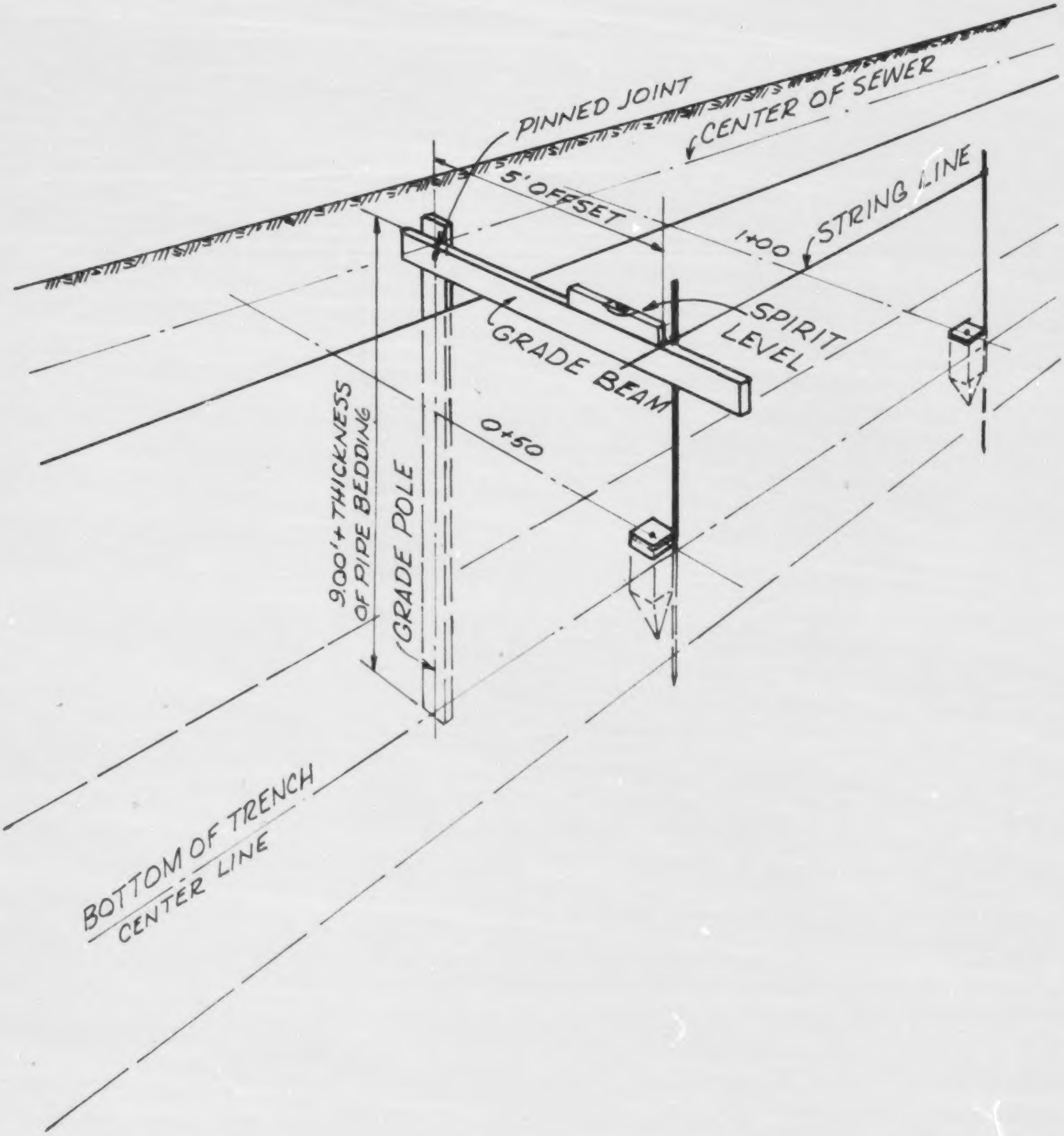

PINNED JOINT
CENTER OF SEWER
5' OFFSET
STRING LINE
1+00
SPIRIT LEVEL
GRADE BEAM
0+50
9.00' + THICKNESS OF PIPE BEDDING
GRADE POLE
BOTTOM OF TRENCH
CENTER LINE

Fig. 3.30. Grade pole

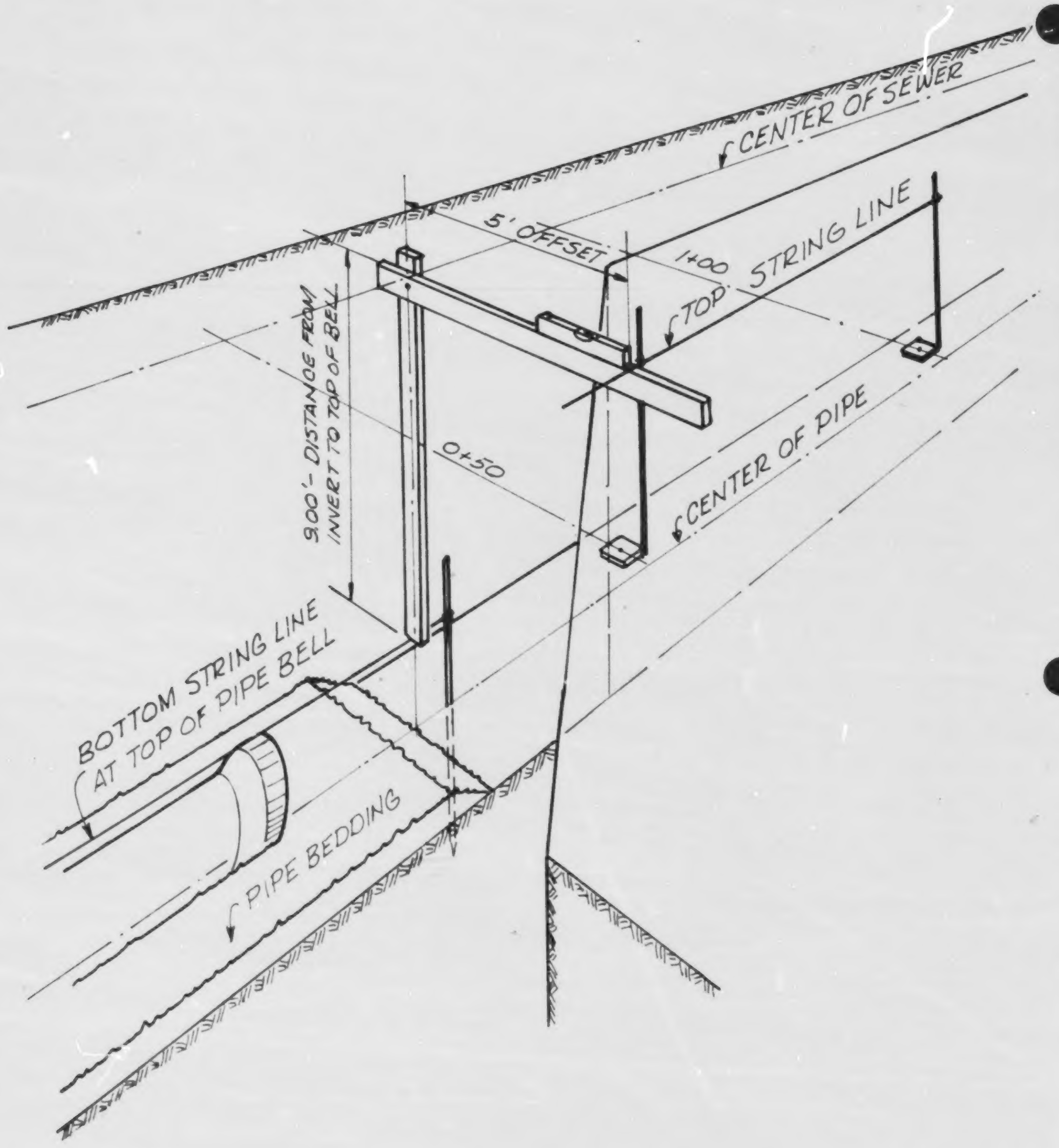

℄ CENTER OF SEWER
5' OFFSET
1+00
℄ TOP STRING LINE
9.00'- DISTANCE FROM INVERT TO TOP OF BELL
0+50
℄ CENTER OF PIPE
BOTTOM STRING LINE AT TOP OF PIPE BELL
℄ PIPE BEDDING

Fig. 3.31. Setting bottom string line with grade pole

arbitrary distance to the invert plus the thickness of the pipe's wall to determine the grade of the pipe bedding and then the arbitrary distance to check the placement of the pipe on the trench bedding.

A more accurate method of controlling the line and grade of a sewer pipe is by the use of batter boards as illustrated in Figure 3.32. This type of control is not used as often as the bottom string line method since more time is required to set the batter boards and they and the string line stretched between them interfere with the placement of bedding material and pipe in the trench.

Sometimes, particularly in the laying of large pipe, the bottom string line will be eliminated and the bedding elevation and pipe elevation will be checked directly by the use of the grade pole as illustrated in Figure 3.33.

When sewer pipe is being laid, a surveyor's level is used to check the elevation of the pipe bedding before the pipe is laid and its invert after it is placed. The procedures outlined in Section 3.521 are used to determine the elevations of the bedding and pipe inverts.

Laser beams also are used to control the line and grade of sewers. The laser beam projector is set at a known elevation above or within the barrel of a previously laid section of sewer and the beam projected forward on line and grade of the sewer to be constructed. If the projector is above the pipe and ground surface, the line and grade can be established by aiming the beam at a target inside a pipe barrel, the grade has to be established by tilting the projector the appropriate angle above the horizontal plane of the instrument. Projectors made for use inside of pipes will have a calibrated dial for this purpose. The horizontal alignment has to be established from the short section of pipe in which the projector is set and adjustment made from ground surface controls as the pipe laying proceeds.

Once the laser beam is set on line and grade, it is used similarly to a string line and the elevation of pipe bedding and inverts established by measuring from the beam's projection onto a target. Periodically the laser beam should be checked to be sure it is still on the proper line and grade. Vibrations or atmospheric conditions can cause the beam to shift from the desired line and grade.

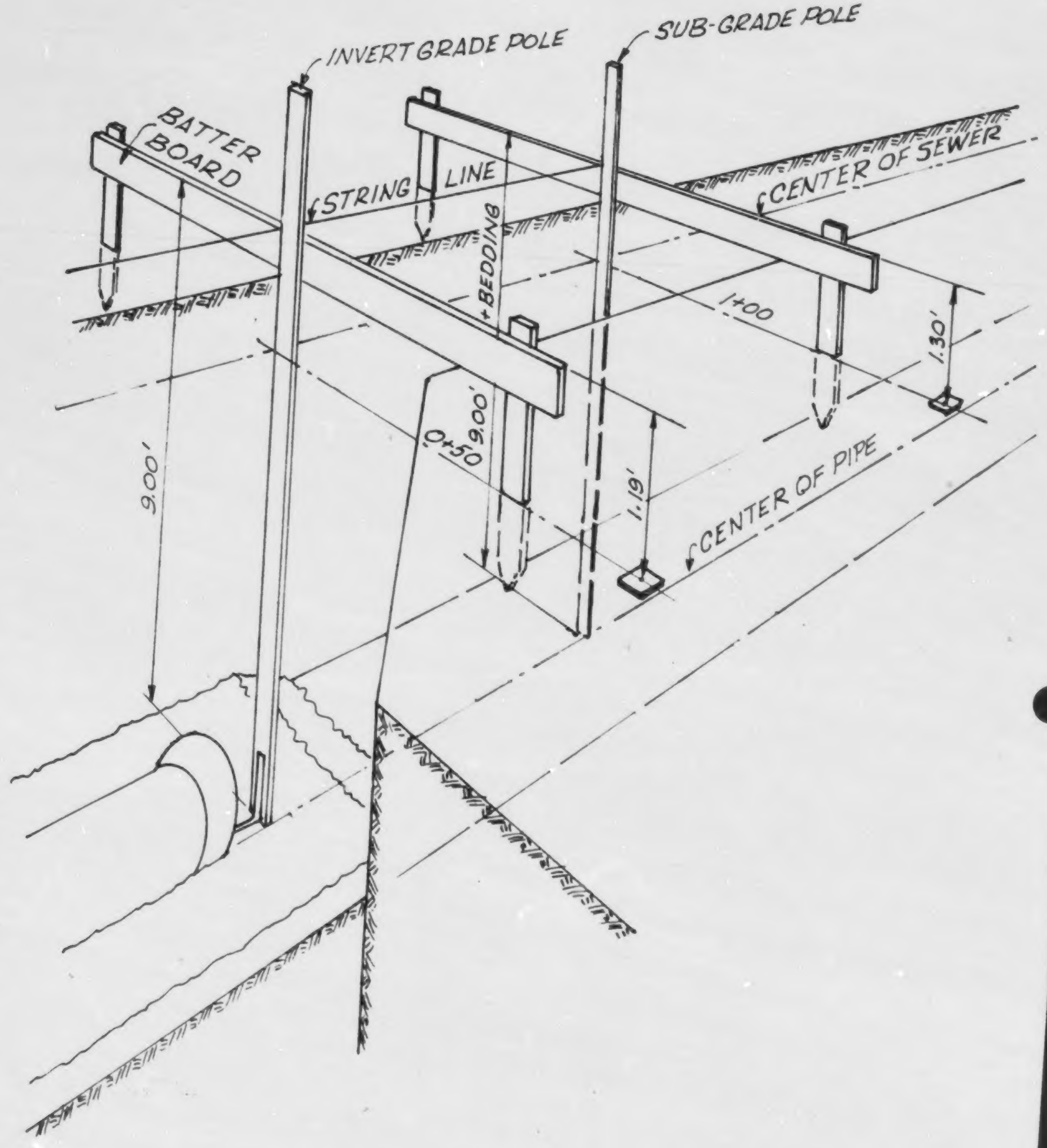

INVERT GRADE POLE
SUB-GRADE POLE
BATTER BOARD
STRING LINE
CENTER OF SEWER
BEDDING
1+00
1.30'
9.00'
0+50
9.00'
1.19'
CENTER OF PIPE

Fig. 3.32. Grade control using batter boards

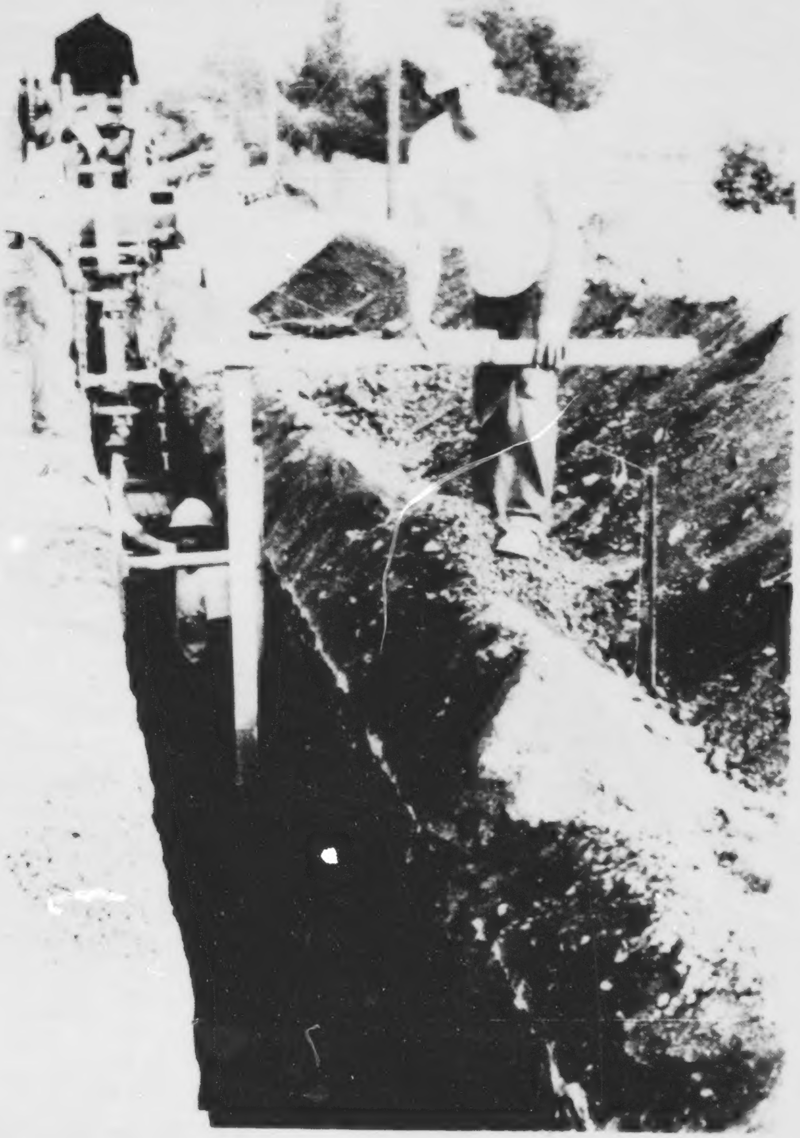


Fig. 3.33. Use of a grade pole

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3.53 Sewer Pipe Bedding and Initial Backfill

Sewer pipe bedding is the material upon which the pipe is laid and serves as its foundation, and initial backfill is that material surrounding the sewer pipe. The type of bedding material, initial backfill, and the care used in placement greatly affect the ability of a pipe to support the load developed by subsequent backfilling of the trench. The following sections briefly describe types of bedding and initial backfill materials and their ability to assist sewer pipe in supporting backfill loads. For more information on pipe bedding and initial backfill, refer to Chapter 9 of the Design and Construction of Sanitary and Storm Sewers, published by the Water Pollution Control Federation, 2626 Pennsylvania Avenue, N.W. Washington, D. C. 20037.

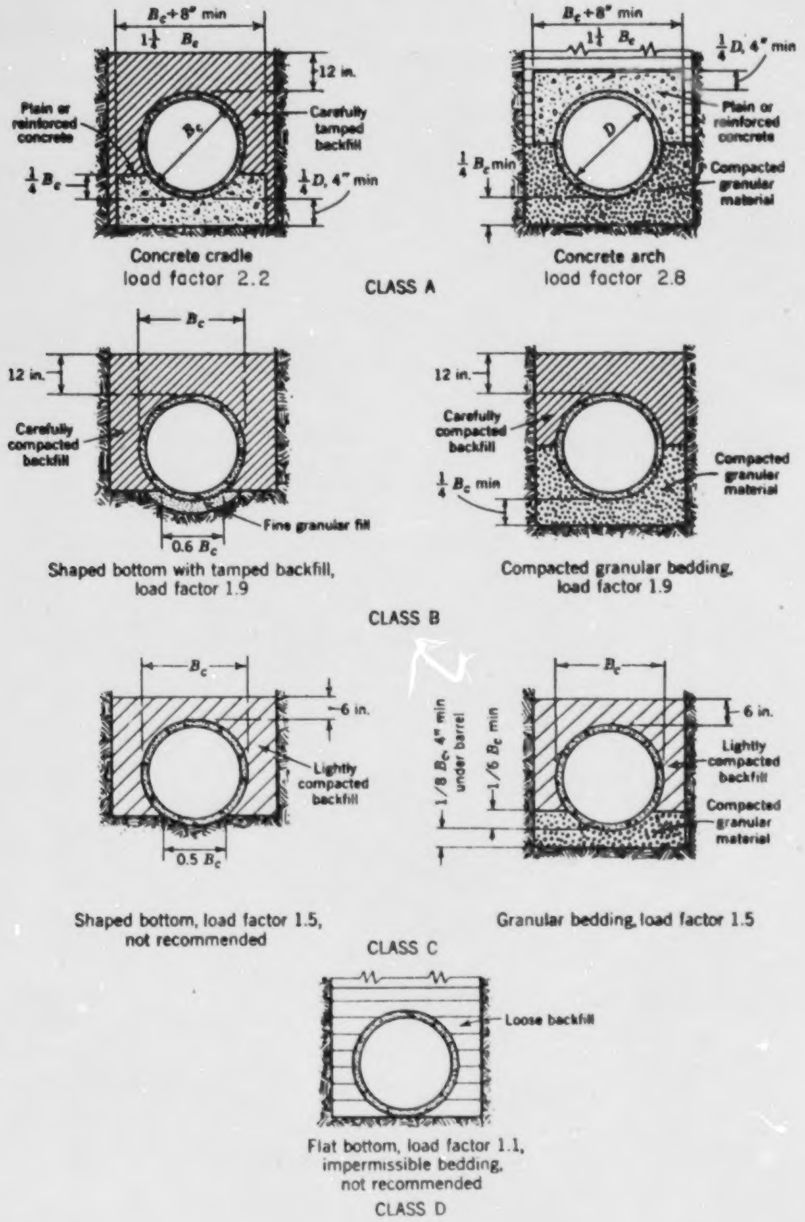
Also, manufacturers of most sewer pipe will, upon request, supply information on the effects types of bedding and initial backfill have upon the load supporting capacity of their pipe.

3.531 Effects of Bedding and Initial Backfill on Rigid Pipe

Manufacturers of rigid sewer pipe usually will specify the load supporting strength of their pipe based on a "three-edged bearing test" conducted in a laboratory and expressed generally as pounds per lineal foot of pipe. For example, the Western Region standard strength of 8-inch diameter vitrified clay pipe is 2,200 pounds per foot, which means the pipe will support this load without cracking.

Since the types of sewer pipe bedding differ from the laboratory test conditions, they have been given a standard class designation indicating the ability of the bedding to assist sewer pipe in supporting trench backfill loads and rated with respect to the three-edge bearing test load. This rating is called a "load factor" with the three-edge bearing load being given a rating of 1.

Classes of Bedding. The standard classes of rigid sewer pipe bedding and their load factors are shown in Figure 3.34. For example, an 8-inch vitrified clay pipe that has a three-edge bearing load supporting strength of 2,200 pounds per foot will have a supporting strength of (2,200 lbs/ft x 1.5) 3,300 pounds per foot when laid on a Class C type of bedding.


B_c+8" min
$1\frac{1}{4}$ B_c
12 in.
Plain or reinforced concrete
Carefully tamped backfill
B_c
$\frac{1}{4}B_c$
$\frac{1}{4}D$, 4" min
B_c+8" min
$1\frac{1}{4}$ B_c
$\frac{1}{4}D$, 4" min
D
Plain or reinforced concrete
$\frac{1}{4}B_c$ min
Compacted granular material
B_c
12 in.
Carefully compacted backfill
Fine granular fill
0.6 B_c
12 in.
Carefully compacted backfill
$\frac{1}{4}B_c$ min
Compacted granular material
B_c
6 in.
Lightly compacted backfill
0.5 B_c
1/8 B_c, 4" min under barrel
1/6 B_c min
B_c
6 in.
Lightly compacted backfill
Compacted granular material
Loose backfill

Concrete cradle
load factor 2.2

Concrete arch
load factor 2.8

CLASS A

Shaped bottom with tamped backfill,
load factor 1.9

Compacted granular bedding,
load factor 1.9

CLASS B

Shaped bottom, load factor 1.5,
not recommended

Granular bedding, load factor 1.5

CLASS C

Flat bottom, load factor 1.1,
impermissible bedding,
not recommended

CLASS D

Fig. 3.34. Classes of bedding for sewer pipe
(Courtesy of WPCF, MOP 9)

Facilitation of Pipe Laying. In addition to assisting sewer pipe in supporting trench backfill loads, a granular type bedding, such as Classes B and C, provides an easy means of establishing a true grade on an imperfect and undercut trench bottom. Also, granular material can easily be arranged to provide holes for pipe bells when laying sewer pipe and to provide for the specified surface contact between the pipe barrel and bedding material.

For these reasons, Classes B and C are the most commonly used types of sewer pipe bedding. Class D is impermissible bedding which means that this type of bedding should not be used.

3.532 Effect of Bedding and Initial Backfill on Flexible Pipe

Flexible pipes obtain their ability to support the load developed by trench backfill from the surrounding soil as they deflect and the sides of the pipe move outward against the soil. Flexible pipe has failed when the amount of deflection resulting from the loading exceeds the amount considered acceptable with respect to the ability of the pipe to convey wastewater and to be cleaned. A deflection not exceeding 5 percent of the inside diameter of the pipe is generally considered acceptable.

The probable deflection of a flexible pipe can be determined from the following formula developed by Professor Spangler of the Iowa State College:

$$\Delta Y = \frac{DekWcr^3}{0.149F/\Delta Y + 0.061\ E'r^3}$$

Where:

ΔY = vertical deflection of the pipe in inches

De = deflection lag factor (generally assumed to be 1.50)

k = bedding constant dependent upon support the pipe receives from the bottom of the trench (0.10 for support through a subtended angle of 90^o).

Wc = vertical load on the pipe (pound per lineal inch)

r = mean radius of the pipe or $\frac{\text{(outside diameter - pipe thickness)}}{2}$

$F/\Delta Y$ = pipe stiffness in psi (as determined by tests) (furnished by manufacturer and ranging from 200 for ABS to 28 for PVC pipe)

E' = modulus of soil reaction (product of the mean radius of the pipe (r) and the modulus of the passive resistance (e) of the side enveloping soil (E' = 700 psi when soils are compacted to a 90% relative density and E' = 300 psi when soils are compacted to a 65% relative density)

For a given load on a flexible pipe the deflection of the pipe will decrease in proportion to the stiffness ($F/\Delta Y$) of the pipe and the compaction of the soil (E'). Also, as the pipe stiffness diminishes, the need for a greater support from the enveloping soil increases.

Therefore, the compaction of the initial backfill around a flexible pipe is very important to assure that it will not be deflected beyond the allowable amount when the trench backfill is applied and compacted.

Additional information on the computation of loading on flexible pipe can be obtained from the Plastics Pipe Institute, 250 Park Avenue, New York, New York 10017 and Chapter 9 of the Design and Construction of Sanitary and Storm Sewers published by the Water Pollution Control Federation, 2626 Pennsylvania Avenue, N.W., Washington, D. C. 20037.

3.533 Bedding Materials

Some comments on the sewer pipe bedding and initial backfill materials illustrated in Figure 3.34 will be helpful in understanding their purpose and construction.

Concrete. Low strength (2,000 pounds/square inch) portland cement concrete is used in the Class A sewer pipe bedding and initial backfill to develop a load factor ranging from 2.2 to 3.4 depending upon their extent and reinforcement with steel. This type of bedding is expensive, and as a consequence it is only used in extremely deep trenches where the type of rigid pipe material and wall thickness combined with a less expensive bedding class will not produce the necessary load supporting strength.

Granular Material. Crushed rock aggregate, with ¼-inch to 3/4-inch particle size, is most commonly used to construct the Classes B and C bedding. Both laboratory and field tests have shown that this type and size of material is superior to sand or pea gravel types of bedding and initial backfill material, with the possible exception of some plastic pipes.

Greater care must be taken in compacting sand bedding material, and it has a tendency to move if water jetting is used to compact the subsequent trench backfill or if the trench area is re-excavated at a later time for the purpose of constructing other facilities. Pea gravel, due to its smooth and somewhat circular shape, also has some of the undesirable characteristics of sand bedding material.

Due to their fairly high load factors (1.5 to 1.9), moderate cost and facilitation of pipe laying, Classes B and C bedding and initial backfill using crushed aggregate are the most commonly used.

Native Material. In some instances, when it is not practical to import material to construct a bedding or the soil conditions are suitable, the native soil in a trench bottom can be used to construct either a Class C or D bedding. By referring to Figure 3.34 it becomes apparent that extreme care must be taken in excavating the trench bottom to true grade in order to produce an undisturbed and compacted trench bottom.

Also it is necessary, when native soil is used, to carefully hand shape the trench bottom to conform to the pipe barrel when Class C bedding is being constructed and to hand dig bell holes in the compacted trench bottom when either the Class C or D bedding is used.

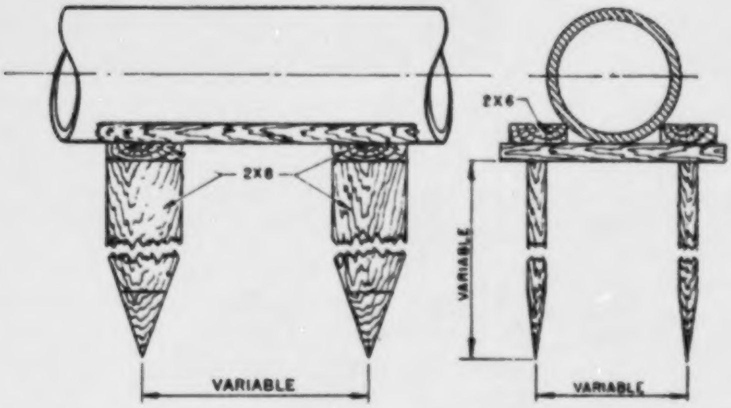
Special Foundations. In most instances, a trench bottom will support the combined load of bedding material, pipe, wastewater, and trench backfill since their total weight will be about the same as the material excavated from the trench for construction of the sewer.

However, sometimes as a result of extremely poor soil conditions (such as fill areas) combined with large diameter pipe, it may become necessary to provide a firm foundation in order to maintain a sewer on a true grade. In these situations, pile supported concrete or timber cradles (saddle piling) are used to support the pipe. Two types of timber pile supports are illustrated by Figure 3.35. Design and construction of this type of sewer pipe support is beyond the scope of this manual.

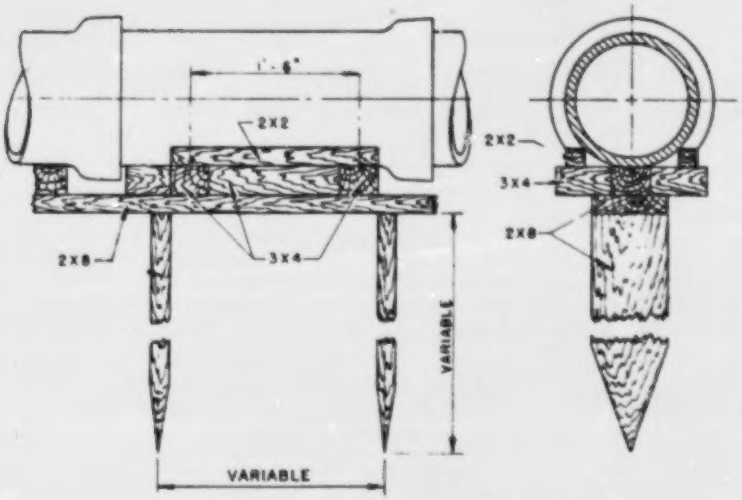
3.534 Bedding Construction

Some sewer pipe bedding and initial backfill construction considerations become apparent as you study the classes of bedding illustrated in Figure 3.34. The following comments point up some of the less apparent considerations.

Class A Bedding. When a concrete bedding is used, the rigid pipe must be supported (usually on concrete blocks or clay bricks) and held to true line and grade when the concrete is placed under the pipe. This is not an easy task since the pipe, particularly in smaller diameters, will tend to float out of alignment and grade.


2X6
2X8
VARIABLE
VARIABLE
VARIABLE

DWARF, OR SADDLE PILING FOR STABILIZING PIPE LINES


1'-6"
2X2
2X2
3X4
3X4
2X8
2X8
VARIABLE
VARIABLE

ANOTHER FORM OF SADDLE PILING

Fig. 3.35. Pile supports for sewer pipe
(Courtesy of Clay Pipe Engineering Manual, National Clay Pipe Institute)

The concrete can be poured into the trench without use of forms providing the bottom is undisturbed, clean and compact, and the trench is not too wide.

When a concrete backfill is used over a granular bedding, the problem of the pipe floating during placement of the concrete is lessened. However, uniform placement is essential to maintaining alignment. Also, a water-proof liner may have to be placed over the top of the granular bedding to stop a rapid flow of water from the concrete into the bedding.

Classes B and C Bedding. When a Class B or C bedding is constructed, it is essential that the bottom and sides of the trench be cleaned of all loose material prior to the placement of the granular bedding material. Initial trench backfill of native material for a height of six inches above the pipe should be free of rocks, mechanically compacted in about 6-inch layers with the proper moisture being maintained in the backfill material. Since it is difficult and expensive to compact native backfill under and around the pipe, granular material, which requires no compaction, is quite often substituted for the native backfill material.

Care should be exercised in using granular materials for pipe bedding and initial backfill which contain significant voids or spaces. Silty or sandy soils tend to move into these voids, particularly where ground water conditions exist which may cause excess loss of pipe support or line and grade change in the pipe after installation is complete. Well graded material with sufficient fines can be used to minimize soil migration into the material.

Class D Bedding. If Class D bedding is used, it is extremely important to have the trench bottom cleaned of all loose material and at a true grade. Care must be taken in the excavation of bell holes not to disturb the foundation under the pipe barrel. In no instance should the pipe rest on the joints and the initial backfill material used to attempt to develop a foundation for the pipe barrel.

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3.54 Sewer Pipe Laying

Most manufacturers of sewer pipe furnish instructions for laying and joining their pipe and these instructions can be obtained by writing the manufacturers. Thoroughly understand these instructions before attempting to lay pipe. Contact the local manufacturer's representative if you need more help.

The following comments provide a general overview of pipe laying and joining procedures and are generally applicable to all types of sewer pipe materials.

3.541 Handling of Sewer Pipe

Care should be taken in unloading and storage of the pipe at the construction site to avoid any damage to the pipe or joints. No pipe should be handled by hand unless it can be done safely without dropping and damaging the pipe or hurting the workers. Proper lifting equipment should be used in removal of the large diameter pipe from the transport vehicle to the ground. The barrel should be supported on a block at the spigot end for its protection.

The proper equipment should be used to lower the pipe into the trench. When large diameter pipe is being laid, the handling equipment should have adequate capacity for lifting and manoeuvering the pipe into the trench. The pipe sling or hook should not damage the pipe. Figure 3.36 illustrates one method of lowering large diameter pipe into a trench.

The following safety rules apply to the handling of sewer pipe:

1. Use barricades, traffic cones and high level flags to identify the work area when unloading pipe within streets.
2. Use the proper mechanical equipment, cable, slings and closed hooks rated for the weight of pipe being lifted.
3. Crane booms should be kept at least 10 feet away from overhead electrical wires.
4. Workers should wear hard hats and be clear of pipe being moved.
5. Pipe stored on the construction site should be surrounded by barricades and flashing lights if stored in a street. Pipe should be blocked to prevent rolling.

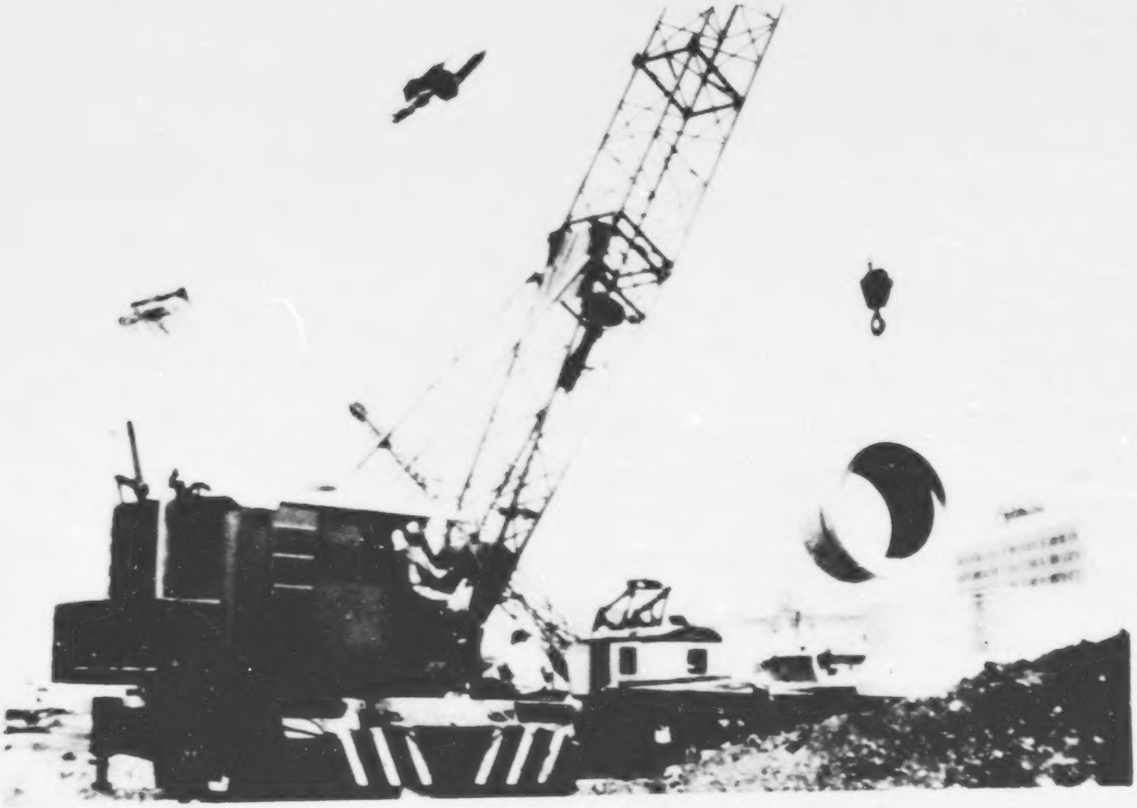

Fig. 3.36. Handling large diameter pipe
(Courtesy of the Bureau of Contract Administration, City of Los Angeles)

3.542 Placement of Sewer Pipe

Small diameter pipe (up to 10 inches in diameter) can be placed directly on the bedding material with the bell end of the pipe facing upstream. Larger diameter pipe should be supported in place with a lifting hook or sling with the bell end of the pipe facing upstream until the jointing operation has been completed.

If the pipe bedding material is properly compacted to grade, no adjustment of the pipe grade should have to be made after the jointing process has been completed. Sometimes it may be necessary to lay large diameter pipe above the design grade and use the impact force and weight of the pipe to bring it to grade. Care must be used, however, to assure uniform support under the entire length of pipe.

3.543 Joining of Sewer Pipe

The method of joining pipe will vary with the type of joint. Most pipes for sanitary wastewater collection systems are furnished with a bell on one end, a spigot on the other end, and a resilient type of gasket to make the joining of the bell of the downstream pipe with the spigot of the upstream pipe watertight. Most resilient gaskets are in the form of an O ring sealed in a groove on the spigot or of mating rings precast in the bell and on the spigot. The basic method of joining pipe with resilient joints is:

1. Clean off the bell and spigot,
2. Lubricate the gasket and seat on the pipe as prescribed by the manufacturer,
3. Guide the spigot end of the pipe into the bell,
4. Push or pull the pipe into place,
5. Inspect the joint for proper seating of the gasket, and
6. Check the alignment and grade of pipe.

When pipe up to 10 inches in diameter is laid in a trench, the joining can usually be done by hand. When pipe larger than 10 inches in diameter is laid, a mechanical method is used to either push or pull the pipe and gasket into place. If the pipe is pushed into place, the pushing force should be applied to the face of the pipe by the use of blocking to prevent damaging the pipe. The pushing force can be supplied by a bar used as a lever with one end shoved into the trench bottom or by the bucket of a backhoe. Larger diameter pipe is usually joined by the use of a cable and winch either placed along the top of the pipes to be joined or within their interior. Care must be used to prevent pulling the previously laid pipe apart at its joint. The several methods of joining sewer pipe with resilient types of joints are illustrated in Figure 3.37.

Manufacturers of pipe with other than bell and spigot joints will furnish instructions on joining their pipe.

Reinforced and unreinforced concrete pipe used for storm sewers are quite commonly joined with a tongue and groove filled with cement mortar. The basic method of joining this type of pipe is:

1. Prepare a cement mortar using water and about equal parts of portland cement and sand,
2. Wet the tongue and groove ends of the pipe with a brush,
3. Fill the groove end of the pipe with cement mortar,
4. Push or pull the pipes together,
5. Check alignment and grade of pipe,
6. Wipe the excess mortar from the inside of the pipe making sure that all voids are filled,[13]
7. Smooth the excess mortar on the outside of the pipe to form a band over the joint using additional mortar if necessary, and
8. Protect the joint from movement, rapid drying, and mechanical damage while the mortar hardens.

If there are lifting holes in large diameter pipe they should be sealed with the material recommended by the pipe manufacturer after placement and jointing of the pipeline.

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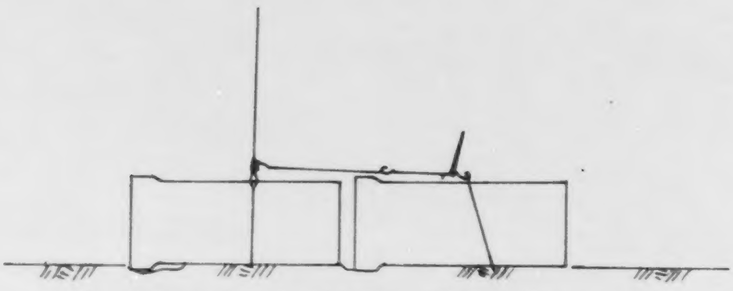
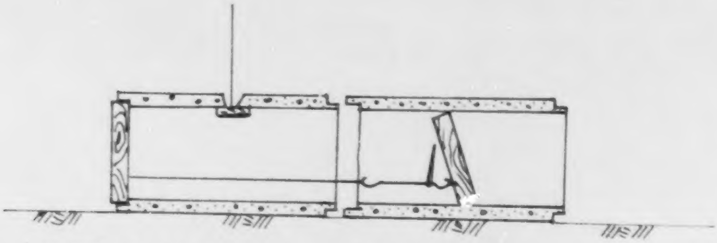
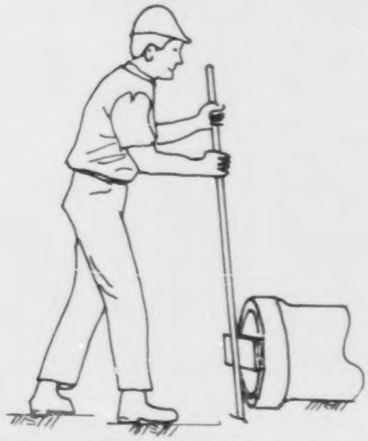
[13] Sometimes the inside joints are filled with a non-shrinking cement mortar.



SLING AND OUTSIDE "COME-A-LONG"



LIFTING HOLE AND INSIDE "COME-A-LONG"



BLOCK AND BAR

Fig. 3.37. Methods of pipe jointing

(Courtesy of Concrete Pipe Installation Manual,
American Concrete Pipe Association)

3.544 Protection of Sewer Pipe

Once the sewer pipe has been laid to a true grade and alignment, it should be protected from displacement or breakage until the trench is backfilled. This protection is particularly important with respect to smaller diameter and rigid types of pipes such as asbestos cement, concrete and vitrified clay pipe. Protection can be provided by immediate placement of initial backfill material.

The upper end of the sewer pipe should be plugged at the end of the work day or if pipe laying is to be stopped for several hours. This action will keep material out of the pipe that is difficult to remove once the sewer is completed and also keep out children and small animals. If the possibility exists that the trench could be flooded, do not plug the ends of the pipe. A plugged pipe in an open trench may float if the trench becomes flooded and would have to be relaid.

3.545 Completion of Pipe Bedding

You will note by referring to the classes of sewer pipe bedding described in Section 3.53 that Class A and B bedding require that the backfill be carefully tamped under and around the pipe to a height of 12 inches above the top of the pipe. When bedding smaller diameter pipe, do not displace the pipe by backfilling and compacting on one side and then on the other side. Also, care must be taken not to lift the pipe from its true grade by over-compacting the backfill under the springline[14] of the pipe.

WARNING

Be very careful when compacting backfill over vitrified clay pipe because this pipe is brittle and may be shattered by the use of too heavy a tamper, or by too strong a stroke from a large tamping machine, or by a heavy vibrating compactor.

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[14] Springline. Theoretical center of a pipe line or the guide line for laying a course of bricks.

3.55 Sewer Appurtenances

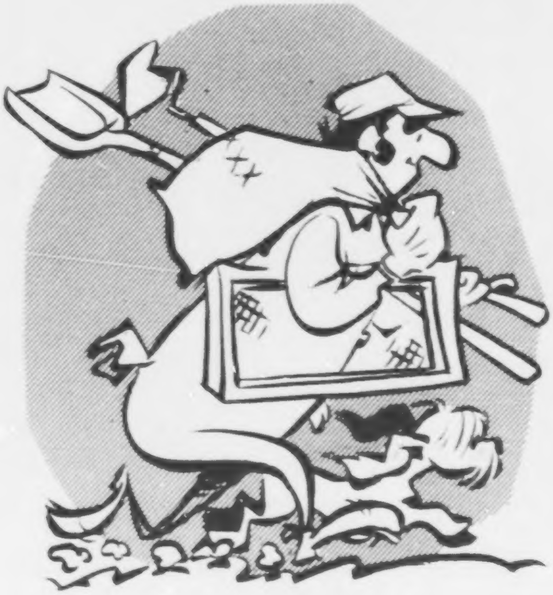
An overview of construction procedures for the sewer appurtenances that collection system workers may have to occasionally construct is provided in this Section. Construction procedures for the other sewer appurtenances listed in Section 3.34 can be obtained by observing construction by contractors and by talking with department of public works inspectors.

3.551 Construction of Manholes

After a hole has been excavated for a manhole, the soil must be prepared to provide a suitable foundation. Compact the soil below the manhole base. If the existing soil does not provide a suitable base, gravel or crushed aggregate can be used.

On straight sewers, the pipe is either laid through or terminates at the manhole. Flexible joints are placed in the pipe just outside the area of the manhole base to allow for any differential settlement between the base and pipe. Water stops should be installed where pipes connect to the manhole to prevent infiltration and exfiltration.

The manhole base is made of unreinforced portland cement concrete poured into a basin formed in the bottom of the manhole excavation. The base should be about one foot greater in diameter than the outside of the manhole barrel (refer to Figure 3.16). The base for manholes on smaller diameter sewers should be poured to the crown of the pipe, the top one-half of the sewer line channel formed into the base and the upper half of the sewer pipe broken out after completion of the manhole. If pre-cast manhole barrels are used, a form matching the bottom tongue of the barrel should be pressed into the manhole base and made level before the concrete hardens. The finished channel, however formed, should be U-shaped as deep as the invert of the pipe.



After the concrete manhole base has hardened sufficiently to support the weight of the manhole barrel and cone (this takes about four hours and hardening can be accelerated with minor sacrifice of strength by the addition of calcium chloride[15] to the concrete mixture), the preformed groove in the manhole base is filled with cement mortar and the first pre-cast concrete manhole barrel set in place. Successive manhole barrels are set on top of the preceding barrel after the groove in the preceding barrel is filled with cement mortar until the combined height of the pre-cast manhole cone and cast iron frame reaches the planned height of the manhole.

The pre-cast manhole cone section is placed in the same manner as the barrels using cement mortar in the tongue and groove joints. Since a combination of manhole barrels and the top cone and frame seldom make exactly the planned manhole elevations, provisions should be made for possible adjustment with pre-cast concrete grade rings or brick masonry to join the top of the manhole cone to the cast iron frame at the desired elevation.

In some areas, manhole cones are constructed with brick and mortar instead of using a pre-cast cone section. A disadvantage of using brick is that the area around the manhole cannot be backfilled immediately because backfilling must wait until the mortar has set.

If the manhole is being constructed in an unfinished street, the cast iron frame and cover are usually left off the manhole and a steel plate is placed over the manhole opening until after the street has been paved.[16] Then the pavement is removed from around the manhole opening, the steel plate is removed and cement mortar is used to attach the cast iron frame to the manhole cone or grade rings. The void between the manhole frame and the pavement is then filled with paving material and compacted to grade. For details regarding the raising of manhole lids, see Chapter 6, Section 6.51.

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[15] Limit addition of calcium chloride to a maximum of two percent of the dry weight of the cement.

[16] Do not place plywood over the manhole opening because it may deteriorate and become unsafe before street construction is completed and the frame and cover installed. Also, if the manhole becomes covered with soil and lost, the metal plate cover may be easily located by a metal detector.

Care should be taken to assure tight joints between the sections of the manhole base, barrel and cone to make them watertight, especially where the ground water level is above the sewer during any time of the year. An asphaltic mastic joint material is manufactured for use in place of cement mortar when leakage of water through the manhole joints is anticipated.

It is a good idea to have the top of the manhole cover about 9 inches above normal ground elevation in easements. This will make the manholes visible and less subject to introduction of dirt and surface water through the manhole cover and into the sewer. In this type of installation the cast iron manhole frame can be attached to the pre-cast concrete cone with epoxy cement instead of cement mortar. Manhole covers may be bolted to the frame to prevent unauthorized removal and the dumping of debris into the manhole.

Some manufacturers will furnish pre-cast concrete barrels and cones with steps meeting safety requirements cast in their walls. thus eliminating the need for their placement in the field. In general, manhole steps should be avoided and ladders used for access.

Since a typical pre-cast concrete manhole barrel or cone will weigh about 2,500 pounds, adequate lifting and placing equipment are required, including a crane, or front-end loader, and a "spider" to secure the manhole section to the lifting cable.

Cast-in-place concrete manhole barrels and cones are becoming more common. However, their construction details are beyond the scope of this manual.

3.552 Construction of Vertical Risers

Vertical risers at the terminals of lateral and branch sewers (see Figure 3.17 and 3.18) are constructed with a long radius 1/4 bend of the same diameter and preferably of the same material and jointing as the sewer pipe. They are supported by a compacted granular bedding material (1/4-inch to 3/4-inch crushed aggregate) placed up to the top of the 1/4 bend. Full diameter pipe risers, again preferably of the same material and jointing as the sewer pipe, are placed on top of the 1/4 bend to a height about 8 inches below the ground surface. Some agencies prefer the construction of risers using a wye and 1/8 bend for ease of maintenance and the preparation of bedding and placement of backfill.

The vertical pipe riser is held in place while the trench backfill is compacted. After compaction of the backfill, a cast iron frame is placed around the riser pipe with the top set to the ground surface and a portland cement concrete collar poured around the frame and pipe. Note from Figures 3.17 and 3.18 that a gasket of fibrous material is placed between the concrete collar and the riser pipe so that any settlement of the cast iron frame and concrete collar will not be transmitted to the riser pipe.

3.56 Sewer Trench Backfill and Compaction

Sewer trench backfill, in most instances, is placed around and over the sewer pipe and up to ground surface. The essentials of proper backfilling are (1) protection of the pipe from breakage from impact or crushing from backfill loading, (2) filling of the excavation, and (3) restoration of the ground surface.

3.561 Backfill Materials

The ideal sewer trench backfill material is one that is immediately available, free of any objects that will damage the sewer pipe and easily compacted. Most backfill materials will not be ideal, and compensation for this fact must be made in the backfilling procedures.

Backfill materials are generally classified as native or imported with sub-classifications under each.

Native Backfill. Native backfill material, as the name implies, is the material excavated from a sewer trench and, in many instances, is the best material for backfill. This material is immediately available, since it is generally stored alongside the trench, and it is not too difficult to remove any large rocks or broken pieces of pavement that are in the material and that might damage the pipe. However, the native material may not be easily compacted and some judgement must be exercised in determining if and how the material can be suitably compacted, or if it will be better to import backfill material. This is particularly important in the initial backfilling of flexible solid wall plastic pipe and reinforced plastic mortar pipe where compaction is essential to good performance. Soils of clay and silt are particularly difficult to compact to required densities.

In most respects, sand is the ideal backfill material and is used as a standard against which the compactability of other types of backfill material is measured. Laboratory tests can determine the sand equivalency of a representative sample of the backfill material, and a trained inspector can determine the approximate degree of equivalency of other samples in the field.

Imported Backfill. Imported trench backfill is quite expensive since there is the cost of hauling and disposing of the native material excavated from the trench combined with the cost of purchasing, excavating and hauling the imported material. For this reason, the use of native backfill material, even with special compactive procedures, should be carefully weighed against the cost of imported material.

Selection of the type of imported backfill material should be based on the ideal qualities listed in this section and modified to balance the cost of the imported material with the cost of obtaining the desired results.

Material being considered for importation should be examined at its source and tests made to determine its sand equivalency.

Suitable imported backfill materials range from crushed aggregate through sand and gravel materials to randomly excavated soil with a minimum sand equivalent of 15. Any material with a lower sand equivalency is probably not any better than the native material.

An important consideration in selecting an imported backfill material is its reaction to surrounding conditions. For instance, one of the disadvantages of using sand backfill is its tendency to move when its side support is removed, such as in subsequent excavations in or near the sewer trench.

3.562 Placement of Backfill

The procedures used for placement of trench backfill, backfill compaction, and surface restoration should provide for protection of the sewer pipe and minimize backfill subsidence (settling) after surface restoration.

Protection of Pipe. If the class of bedding and initial backfill requires placement of native or imported backfill around the pipe, hand shoveling should be used to place material from the ground surface around both sides of the pipe at the same time so that the pressure of uneven backfill will not move the pipe out of alignment. The initial backfill should be compacted in accordance with the specifications for the class of bedding (see Fig. 3.34), under the bottom of the pipe to eliminate any voids in this critical area of pipe support. This type of backfilling is generally carried to about 6 to 12 inches above the pipe and must be very carefully placed and compacted to avoid damage to the sewer.

Another, less satisfactory, method of placing the backfill around the pipe is by drifting in the material. In this method the backfill material is pushed into the lower end of the trench by a bulldozer or front-end loader and allowed to slide down the slope that the previously placed material will assume. The disadvantage of this method is that the initial backfill is not compacted and larger particles of backfill material will slide down the slope faster than the fine material and surround the pipe.

Completing Backfill. After initial placement of backfill material around and over the pipe, mechanical equipment, such as bulldozers or front-end loaders, is used to move the backfill material from alongside to inside the trench. If the backfill material particle size is not too large and the trench not too deep, the material may be dropped vertically into the trench. Otherwise, the backfill material should be drifted into the trench as described in the preceding paragraph. Figure 3.38 illustrates a typical backfilling operation.

The method of compacting the backfill material as described in Section 3.563 will influence the method used for placing the material in the trench. For example, if the material is to be compacted in lifts, it will be necessary to drop the material vertically into narrow trenches or to drift and spread with mechanical equipment in wide trenches.

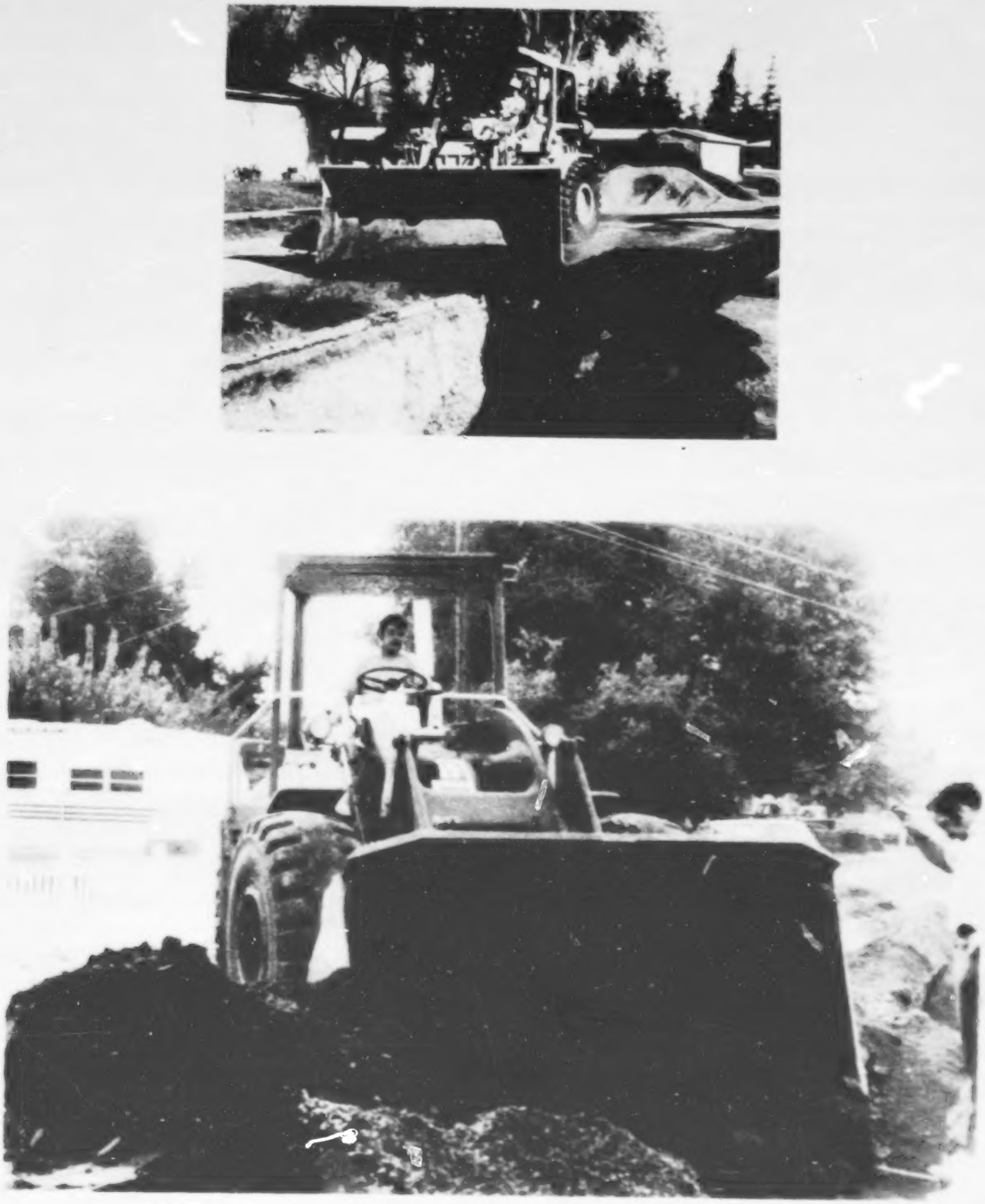


Fig. 3.38. Placing backfill

Removal of Trench Shoring. Removal of trench shoring in a safe manner requires coordination with the placement of the trench backfill. The shoring should not be removed until the need for workers to be in the trench no longer exists and the backfilling operation has started.

Hydraulic-actuated aluminum shoring can be decompressed and removed from the topside of the trench completely ahead of placement of the backfill material and for this reason is an excellent type of shoring for most trenches.

When steel screw-type trench or timber braces are used by choice or necessity, closer coordination with placement of the backfill is required. In this instance the backfill should be dropped or drifted to the level of the lowest trench brace. Then after its removal, the trench should be backfilled to the level of each successive brace until all are removed. The vertical shores still will be in place, it is usually necessary to pull them out with a crane or the bucket of a front-end loader. Backfilling equipment in the vicinity of the trench brace removal operation should be stopped to avoid possible collapsing of the trench walls while a brace is being removed by a worker in the trench.

When either timber or steel sheet piling is used for trench shoring, it may be left in place if its removal will damage the sewer pipe or adjacent facilities. However, the upper several feet of the sheeting should be cut off and removed to avoid interference with surface restoration or future underground construction.

3.563 Compaction of Backfill

Compaction of trench backfill has no beneficial effect upon the performance of a sewer. The load supported by a sewer pipe increases to a certain extent as the backfill material is made more dense by compaction. However, it is essential that trench backfill material be well-compacted to avoid its subsequent settling that could cause damage to utilities that cross the trench, to structures adjacent to the trench, or require the repaving of overlying street surfaces to eliminate depressions caused by subsidence of the backfill.

The following sections outline the more common methods of compacting backfill material and measuring their effectiveness.

Water Compaction. Jetting trench backfill material with water is one common method of compaction. When the type of backfill material is suitable, this type of compaction is simple, quick, and economical, but inferior to mechanical compaction. Generally, backfill material with a sand equivalent of less than 15 is not suitable for compaction by water jetting.

Equipment for compaction by water jetting consists of a 1 1/2 to 2-inch diameter jet pipe long enough to reach to within 2 feet of the top of the pipe, hose, and a water supply that will produce a 10 to 15 pounds per square inch pressure at the jet nozzle.

The jet pipe is pushed into the backfill with the water running until the nozzle is within about 2 feet of the top of the pipe and left in place until water reaches the trench surface. Usually the backfill material will stop subsiding about the time water reaches the surface. The jet pipe is then moved up the trench, generally about 10 feet, and to the opposite side of the trench. The jetting operation is then repeated. In a wide trench it may be necessary to shorten the distance between the jetting locations. A good rule is to over-jet rather than under-jet. Figure 3.39 illustrates compaction of a trench backfill by water jetting.

If a trench is deeper than 12 feet, the backfill material should be placed and compacted in two or more lifts or layers before filling and compacting the remainder of the trench.

Vibrating equipment is sometimes used along with the water jetting to develop a greater compaction of the backfill.

The disadvantages of compaction with water jetting are (1) not suitable for all types of soils, (2) subject to wide variations of results depending on procedures used, (3) trench surface cannot be restored until the trench backfill has dried out, and (4) the amount of compaction is less than that obtained by mechanical methods.

"Puddle drains" consisting of a short length of perforated pipe laid in the bottom of the sewer trench and projecting through the manhole wall with a removable cap on the end may be installed and used as an aid to drying out trench backfill. These drains also can be used by maintenance crews to drain groundwater out of a trench when repairs are to be made.

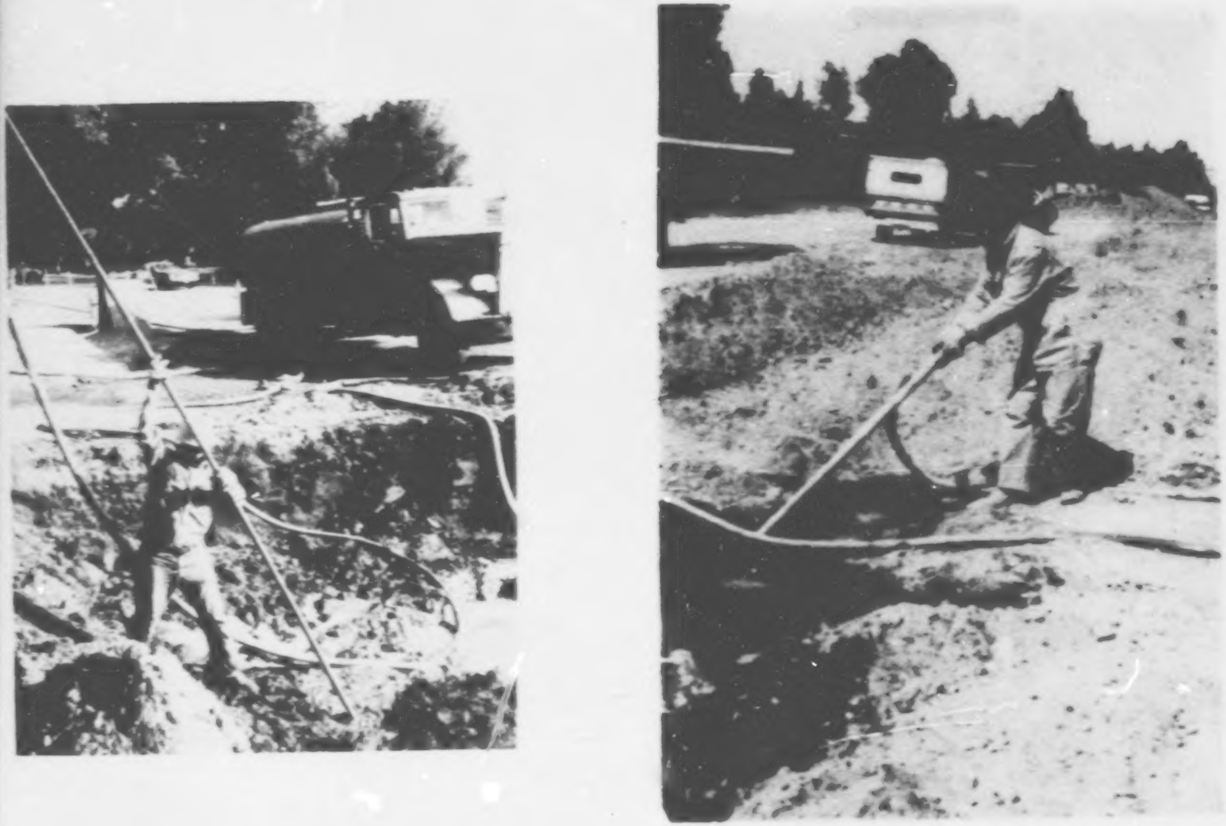


Fig. 3.39. Compaction of trench backfill by water jetting

Flooding of a trench backfill with water is a less satisfactory method of compacting with water and is not used too often. The procedure is to make a shallow ditch along the trench backfill and flood it with water and at the same time rod the backfill material from top to bottom until the required compaction is obtained. The rod is a 2 to 2.5-inch pole that is used to push the mud and water on the surface of the trench to the bottom of the trench and to fill the air voids in the backfill material.

A disadvantage of using water compaction after repairing a sewer located in a street is that the soil should dry before patching the street. Otherwise soft spots could develop under pavement patches and require repaving again.

Mechanical Compaction. Properly performed mechanical compaction of trench backfill should be used when subsequent subsidence of the backfill could result in expensive or inconvenient street surface restoration or damage to adjacent structures.

Equipment for mechanical compacting backfill material consists of hand held air tampers, hand held gasoline driven impactors, plate vibrators, vehicle mounted impactors, and vibrating and sheep foot rollers.

When mechanical compacting equipment is used, the backfill material has to be placed in lifts matching the compacting capabilities of the equipment used. For instance, 4-inch lifts are about maximum for hand held compacting equipment; whereas lifts up to 3-feet thick can be compacted with vehicular types of impactors.

The moisture content of the backfill material to be compacted is very important. Material with insufficient moisture will tend to bulk and rebound under the compactive effort; whereas material with too much moisture will be moved away (pumped) from the compactive effort and displace the adjacent material. An approximate method to determine the proper moisture content is to add water slowly to a dry sample in your hand until it can be formed into a compact ball.

Compaction of narrow trenches requires the use of hand held equipment and numerous shallow lifts. For this reason, an economical alternative to mechanical compaction of native material may be the use of imported backfill material that can be compacted by jetting with water.

Mechanical compaction becomes more practical in wide trenches where vehicular compaction equipment with deeper lifts of backfill material can be used to produce the required compaction at a reasonable cost.

Quite often water jetting and mechanical compaction are used together to compact trenches excavated in paved areas. When this procedure is used, the backfill material is first jetted and then the trench refilled to the paved surface with the rock material to be used for the base of the repaving. The trench is allowed to "dry" for several days. After drying a vehicular impactor is used to compact the surface of the trench just prior to repaving.

The main disadvantages of mechanical compaction of trench backfill are: (1) length of time required; (2) maintenance of shoring during compaction in lifts; (3) excessive impact can damage pipe; (4) high costs.

Measurement of Compaction. The amount of compaction that has been obtained in trench backfill material is determined by measuring the density of the "in place material" in pounds per cubic foot and comparing it with the maximum obtainable density of the same material under ideal conditions. This is called the relative compaction since the test relates the actual density to the maximum obtainable density.

Determining the in place density of the backfill material after compaction and the maximum obtainable density of the backfill material is a complicated procedure requiring the services of a well-equipped and staffed soils testing laboratory using standard procedures developed by state departments of public works and the American Society for Testing and Materials.

A common requirement is for compaction of the backfill material in the lower area of the trench to 90 percent of maximum and the upper 3 feet to 95 percent of maximum.

3.564 Surface Restoration

The final operation in constructing a sewer is restoring the ground surface disturbed by the construction process. Usually the surface is restored to its original condition.

In Easements. Surface restoration over sewer trenches in easements usually requires removal of excess dirt and rocks that may have been excavated from the trench, followed by bringing in top soil in cultivated areas and replanting in landscaped areas.

In Paved Areas. Surface restoration over trenches in paved areas requires the compaction of the trench surface by mechanical means, re-excavation of the backfill material (if compaction does not produce the required depth) to the sub-grade of the pavement, and repaving with materials similar to the original pavement.

3.6 SEWER CONSTRUCTION INSPECTION

3.61 Need for Inspection of Completed Sewers

Imagine what could happen if a new wastewater collection system was put into service and something was wrong with the system. A disastrous mess could develop and repairs would be very difficult. Proper testing and inspection of a new sewer system before placing it in service can prevent serious problems from developing and avoid considerable grief.

New wastewater collection system construction materials and procedures are inspected by a public agency-owner to:

1. Assure compliance with the plans, specifications, and safety regulations governing the work.
2. Alert the design engineers to any modification of plans required to meet unexpected conditions found during construction.
3. Minimize need for future maintenance of wastewater collection system by assuring close compliance with plans, specifications and good construction practices.
4. Provide a record of the construction progress and "as-built" plans of the wastewater collection system that is buried, but cannot be forgotten. Locating portions of the system in the future can be very difficult and costly without accurate "as-builts" showing the exact location of facilities in the system.

The "Public Works Inspectors' Manual" written by Silas R. Birch, Jr., Inspector of Public Works, City of Los Angeles, California, and published by Building News, Inc., 3055 Overland Avenue, Los Angeles, California 90034, provides an excellent reference on the purposes and procedures for inspection of public works construction, including wastewater collection systems.

3.62 Duties of An Inspector

The duties of a wastewater collection system construction inspector, performed under the supervision of a registered professional engineer, are to act as an observer and reporter of materials and procedures used for constructing the system. In small towns or sanitary districts, the inspection may be shared with the design and project engineer.

Any major deviation from the plans, specifications, safety regulations and good procedures for construction of a collection system are accurately reported by the inspector to the project engineer for remedial action. Minor deviations are usually eliminated in the field by conferences between the inspector and the contractor's superintendent of construction.

An inspector should attempt to anticipate field conditions, such as previously undetected utilities or other obstructions that may require a change in the location of a planned sewer, and submit a prompt report to the project engineer in order to minimize any delays and costs caused by correcting the situation. The inspector must be sure that the installation procedures, materials, and workmanship conform with the project specifications.

Inspectors also must prepare written reports that will

1. Provide a daily measure of construction progress, record compliance with safety regulations, and call attention to any unusual incidents;
2. Provide a monthly measure of completed work that can be used as a basis for progress payments to the contractor;
3. List the final items of work to be completed prior to acceptance of the project by the public agency-owner;
4. Indicate the location of the buried wastewater collection system, generally submitted in the form of "as-built" plans. Locations should be measured accurately from several permanent surface points to the critical points of the system so that they can be relocated easily.

3.63 Qualifications of An Inspector

A sewer construction inspector, in order to adequately perform his duties, should have knowledge of: (1) methods and equipment used in wastewater collection system; (2) fundamentals of construction surveying; (3) the physical properties, types and uses of sewer construction materials; (4) procedures and equipment used in testing construction materials; and (5) laws, codes, ordinances and standards applicable to public works construction in general and wastewater collection system construction specifically.

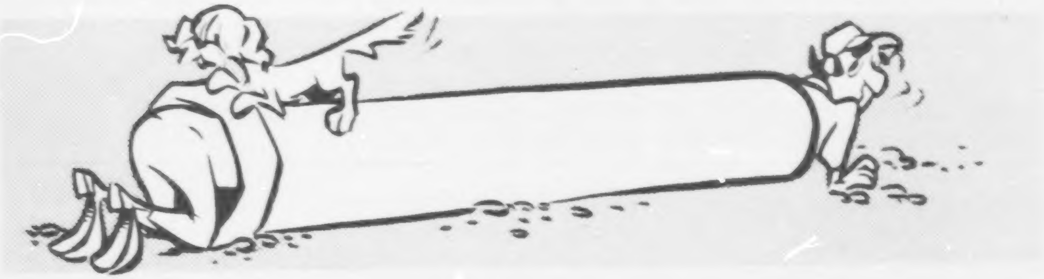
A well-prepared sewer construction inspector also should have the ability to: (1) read and interpret plans, specifications, ordinances and regulations applicable to wastewater collection system construction; (2) determine if construction materials conform to specifications; (3) keep accurate records, gather data and prepare accurate reports; (4) make simple engineering calculations; and (5) establish and maintain cooperative working relations with those contacted in the course of work, including contractors and general public.

3.64 Inspection of Construction Materials

Wastewater collection system construction materials should be inspected the first time for compliance with specifications as close as possible to the manufacturing site. This inspection can minimize the delays and costs resulting from the replacement of rejected materials. In all situations the materials should be inspected for defects prior to their installation.

3.641 Sewer Pipe

Most public agencies rely on the integrity and quality control of the manufacturer of small diameter pipe (up through approximately 24-inch diameter) to insure production of pipe that meets specifications. However, thorough inspection of the pipe should be made after delivery to the job site to detect any damage to the pipe resulting from handling after manufacturing, including loading, transportation and unloading.



On the other hand, most public agencies will send an observer to the plant of the manufacturer of large diameter pipe to observe and certify to the manufacturer's testing of representative samples of pipe for compliance with specifications. As in the case of smaller diameter pipe, large diameter pipe should be inspected after delivery to the job site to detect any damage resulting during the delivery. Some agencies hire an independent testing laboratory to test and certify that pipe meets all specifications.

The procedures used in testing the various types of pipe used for sanitary and storm sewer construction are beyond the scope of this manual. For further information on these procedures, references can be made to the publications of the pipe manufacturers and the standards for testing procedures published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

3.642 Wastewater Collection System Appurtenances

As in the case of small diameter sewer pipe, most public agencies rely upon the integrity and quality control of the manufacturer of collection system appurtenances, such as precast concrete manhole barrels, cast iron frames and covers for manholes and risers, wyes and tees, to assure compliance with specifications. On-the-job site inspection is used to detect any visible defects missed by the manufacturer or resulting from handling.

3.643 Pipe Bedding and Trench Backfill Materials

An inspector should arrange to have representative samples of sewer pipe bedding and imported trench backfill tested for compliance with the specifications for these materials. Most inspectors are not trained or equipped to perform these tests. However, by comparing samples of materials that meet their specifications with subsequent deliveries, an inspector generally can detect and reject material not meeting specifications.

Information on soil testing procedures can be obtained from the American Society for Testing and Materials and the materials and research departments of most state public works or transportation agencies.

3.644 Portland Cement Concrete

Portland cement concrete used for constructing load bearing structures should be tested with respect to its composition, workability, strength and density. An inspector will use the services of his agency's materials testing laboratory for conducting most of these tests.

3.65 Inspection of Construction Procedures

Proper inspection of the procedures used to construct sanitary and storm sewers using materials meeting specifications will assure production of a wastewater collection system that will function in accordance with the engineer's design and should require the minimum of maintenance.

3.651 Location of Utilities

Be sure to ask utility companies to send a representative (locator) to locate their buried lines in the vicinity of a construction project. See Section 3.512 for more details.

If the actual locations of the underground utilities are diffirent from that shown on the construction plans and require a change in the location of the proposed sewer, the inspector should immediately notify the project engineer of the location of the utilities and need for change of plans.

An inspector also should be familiar with the procedure to be followed in protecting a utility from damage if it is exposed during construction. Many utility companies want to have their own employees inspect the utility and restore any protective coating damaged by construction activities. The inspector also should determine that an exposed utility is protected from damage during trench backfilling and compaction operations.

When a sewer is constructed under gas service lines, it is a good practice to advise the utility company when the project is completed and request their inspection of building connections to each service line to determine if any gas leaks have been caused by the construction.

3.652 Trench Excavation

The following are the major items that should be inspected for conformity with construction requirements during excavation of a sewer trench:

1. Compliance with the traffic control and other regulations established by a street encroachment permit.

2. Correct line and grade for the trench excavation (refer to Section 3.52 for sewer alignment and grade control).

3. Compliance with trench excavation safety regulations (refer to Section 3.514).

4. Cleaning of trench bottom to provide a solid base for sewer pipe bedding.

3.653 Pipe Laying

During the pipe laying operation the following items of work should be inspected:

1. Sewer pipe bedding placed to prescribed depth and grade (refer to Section 3.524).

2. Sewer pipe laid to grade with joints made in accordance with manufacturers' instructions (refer to Section 3.524 and 3.54). Each sewer pipe in place must be closely inspected for any visible defects such as a cracked bell or an unseated gasket. The gradient of each sewer pipe should be double checked by placing a spirit level along the top of the pipe barrel.

3. The interior of the pipe should be free of bedding materials, dirt, boards, or other debris that could create problems in the wastewater collection system when it is put into service.

3.654 Construction of Appurtenances

Construction of major wastewater collection system appurtenances should be inspected for the following:

1. Location of wyes and tees in the main and lateral sanitary sewers to provide connections for designated locations of building sewers. Their location must be recorded for future recovery if building sewers are constructed after backfilling the main sewer trench.

2. Manhole bases poured on firm foundations; continuous support under sewer pipes between edge of bases and undisturbed trench bottom; construction of channels to proper width and grade; placement of manhole barrels in vertical alignment with watertight joints; and placement of cast-iron frames and covers at proper grade (refer to Section 3.551 for manhole construction details).

3. Vertical riser bends should be surrounded by compacted aggregate to support the weight of the vertical piping; the vertical pipe insulated from surface loading applied to the frame and cover; and the cast-iron frame and cover set to proper grade (refer to Section 3.552 for construction details).

3.655 Trench Backfilling and Compaction

An inspector should check the following [illegible] sewer trench backfilling:

1. Placement of backfill material a[illegible] the sewer pipe in a manner that will not ca[illegible] or vertical displacement of the pipe.

2. Placement of backfill material in a manner that will not cause heavier material to accumulate around and adjacent to the sewer pipe.

3. Placement of backfill material in lifts and with moisture content matching required compaction method.

4. Compaction of the trench backfill in the manner and amount specified (refer to Section 3.563). The amount of compaction obtained by the compactive efforts are determined

by relative compaction tests beyond the scope of training and equipment provided most inspectors. However, an inspector along with the project engineer should arrange for an appropriate number of such tests to determine the adequacy of compaction. An inspector should develop by experience a feel for the amount and type of compaction obtained.

5. After backfilling is completed, visually inspect the lines for leaks, displaced pipe, and other signs of damage.

3.656 Surface Restoration and Clean Up

The manner and procedure for surface restoration will vary with the surface conditions existing prior to construction of the wastewater collection system with the purpose being to restore the surface as nearly as possible to its original condition. In many instances the surface will be under the jurisdiction of an agency apart from the public agency-owner of the system and the type of, and procedure for, surface restoration will be specified by that agency. The inspector must require the contractor to follow these specifications. During surface restoration the inspector should have manholes or other sewer openings covered and protected from the introduction of surfacing materials and the entrance of storm water runoff which may carry silt and debris into the newly constructed sewer.

Inspection of the final cleanup of the construction area is important since it is the last opportunity to have a contractor complete those jobs left to the end before pulling the last workers off the job. The inspector also should use a list of uncompleted work developed from a final inspection as a guide for the work to be completed before recommending acceptance of a project.

3.657 Final Inspection

Final inspection of a wastewater collection system construction project, if the inspection of each phase of the construction has been thorough, should serve as a final check on the small items of uncompleted work remaining, particularly with respect to surface restoration and clean up, to make the project acceptable to the public agency-owner.

Many agencies will have a representative of the department that will be responsible for maintenance of the completed wastewater collection system accompany the inspector at the time of final inspection for the purpose of pointing out any defects in the system that will cause maintenance problems. If time or costs do not allow TV inspection of the entire job, the design engineer, the inspector, and a maintenance worker may each identify portions of the job they believe should be given a final inspection with TV. Inspection procedures using TV equipment are outlined in Chapter 4, "Inspecting and Testing Collection Systems."

In large diameter sewers, a final inspection should include a "walk through" inspection to determine that all the construction tools and debris have been removed. Final visual inspection of sewer lines may reveal standing water and other indications of grade misalignment.

A thorough and detailed list of items of work to be completed should be made at the time of the final inspection with copies being distributed to the contractor and project engineer.

3.66 Testing of Sewers

Prior to recommending acceptance of a sewer system, and preferably after the sewer trench has been backfilled and compacted, but before the surface is restored, the sewer system should be tested by the use of a water or air test to determine the ability of the system to withstand the infiltration of ground water, exfiltration of wastewater, or intrusion of tree roots. See Section 3.7, Testing, for details on how to use water or air tests.

Some owner-agencies specify a "Go-No Go" test at 95 percent of the average pipe diameter after installation, backfilling and compaction of a wastewater collection system is completed. The "Go-No Go" testing device consists of a double tapered cylindrical plug of unyielding material having a diameter equal to 95 percent of the average diameter of the pipe to be tested. The plug has pulling rings at both ends, to which pulling and tap lines are attached. Either or both the pulling and tag lines are marked so that the distance that the plug has been pulled into a sewer can be determined.

The "Go-No Go" test is conducted by pulling the test device through a completed sewer from manhole to manhole. If a flexible type pipe has been deflected beyond 5 percent of its diameter, a rigid type of pipe has been crushed, a joint offset more than 5 percent of the pipe diameter or a building sewer connection is protruding into the main line, the "Go-No Go" device will not pass the obstruction.

The location of the obstruction can be determined by use of the distance markings on either the pulling or tag line and the pipe re-excavated and the obstruction removed.

3.67 Construction Records

Previously it was pointed out that a sewer construction inspector is expected to submit comprehensive reports to the project engineer on the project he is inspecting. The following paragraphs describe the contents of these reports in more detail.

3.671 Daily Reports

The purpose of a daily report is to provide the project engineer an overview of the project progress and a source of information for answering questions raised later with respect to conduct of the work.

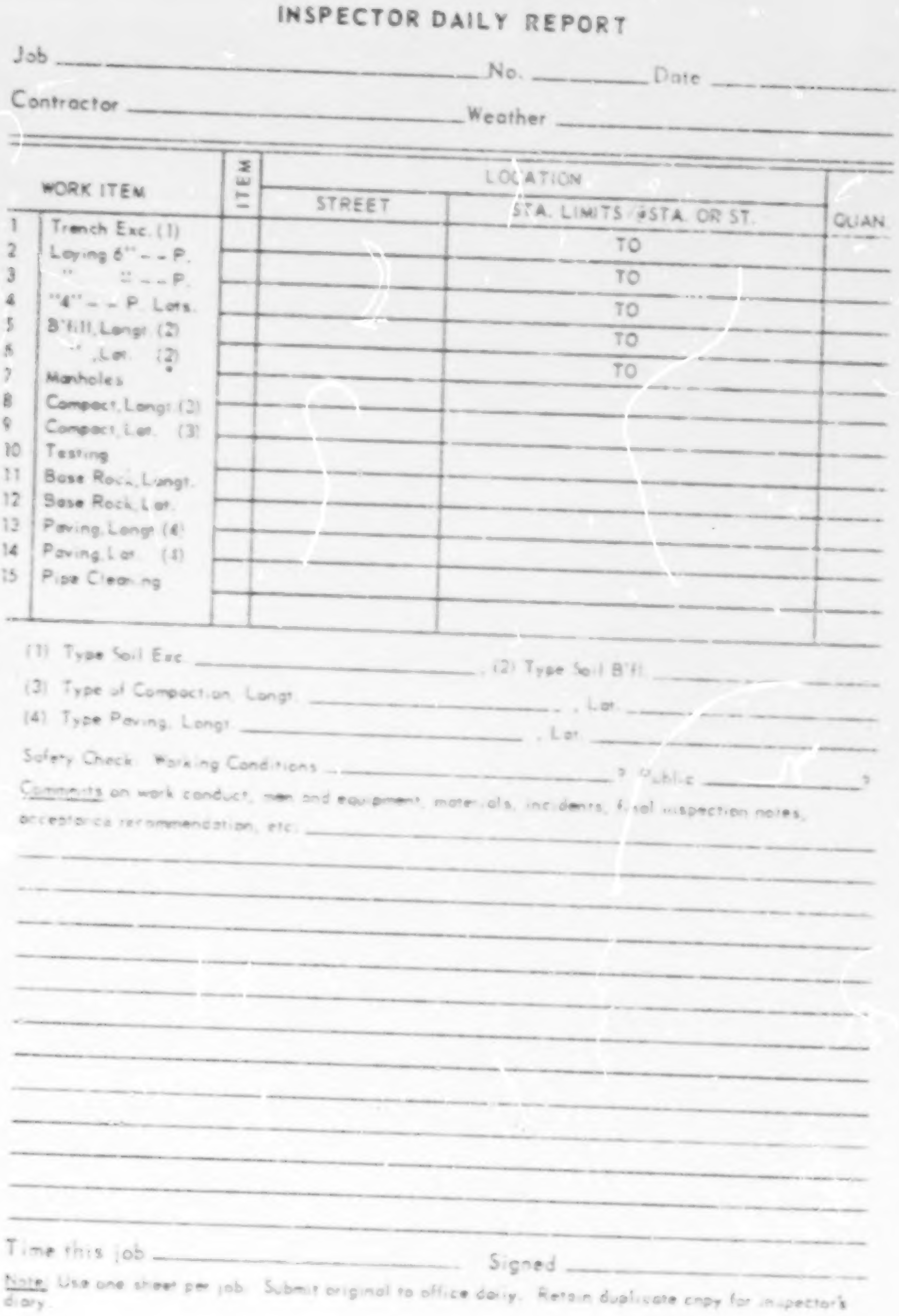
An inspector should report daily on the weather conditions, amount of work performed on the project, type of soil encountered during excavation of sewer trenches, working conditions with respect to safety regulations, number of men and type of equipment being used and any significant incidents that may have occurred during the day. Figure 3.40 illustrates a form used for submission of an inspector's daily report. Each agency develops forms to fit their particular reporting requirements and may include such additional items as number of yards of concrete placed and amount of sheet piling driven.

3.672 Monthly Reports

The monthly reports of an inspector generally consist of information that will be used by the project engineer to determine the amount of work completed during the month and the amount to be paid the project contractor for completed work. Figure 3.41 illustrates a form used to submit monthly reports on amount of completed work.

3.673 Building Sewer Locations

In most instances wyes or tees are placed in main sewers for building sewer connections and are buried by the main sewer trench backfill before construction of the building sewer. The inspector must record the location of a wye or tee before it is buried. This is usually done by measuring the distance along the main sewer from the nearest downstream manhole and entering this data on a Building Sewer Location form illustrated by Figure 3.42.



INSPECTOR DAILY REPORT

Job ____________________ No. ________ Date ____________

Contractor ____________________ Weather ____________________

	WORK ITEM	ITEM	LOCATION		QUAN.
			STREET	STA. LIMITS/#STA. OR ST.	
1	Trench Exc. (1)			TO	
2	Laying 6" – – P.			TO	
3	" " – – P.			TO	
4	"4" – – P. Lats.			TO	
5	B'fill, Longt. (2)			TO	
6	" ,Lat. (2)				
7	Manholes				
8	Compact, Longt. (3)				
9	Compact, Lat. (3)				
10	Testing				
11	Base Rock, Longt.				
12	Base Rock, Lat.				
13	Paving, Longt. (4)				
14	Paving, Lat. (4)				
15	Pipe Cleaning				

(1) Type Soil Exc. ____________________, (2) Type Soil B'fl. ____________

(3) Type of Compaction, Longt. ____________________, Lat. ____________

(4) Type Paving, Longt. ____________________, Lat. ____________

Safety Check: Working Conditions ____________________? Public ____________?

Comments on work conduct, men and equipment, materials, incidents, final inspection notes, acceptance recommendation, etc. ____________________

Time this job ____________________ Signed ____________________

Note: Use one sheet per job. Submit original to office daily. Retain duplicate copy for inspector's diary.

Fig. 3.40. Inspector's daily report form

REPORT OF QUANTITIES INSTALLED

As of (Date): ____________________

Job: ____________________

Installer ____________________
Engineer ____________________
Contractor ____________________

Final Report ☐
Progress Report ☐
ACP ☐
VCP ☐

STREET	4" B.S.	6" Main	8" Main	__" Main	M.H.	F.I.	Extra Wyes	

Instructions to Inspector:
Make report in duplicate.
Progess report as of last day of month, when job not complete.
Final report when installation has been completed.
Make notes about unusual items.

____
Inspector

Fig. 3.41. Monthly report form for completed work

BUILDING SEWER LOCATION

PROJECT OR TRACT NO. ______________________________ UNIT NO. ______

REET ____

FROM ______________________ TO ______________________

MAIN OFFSET FROM C/L __________ STREET WIDTH __________ SIZE OF MAIN __________

		MAIN Connections						
MH No.	Station	Type	Size	Side of St	Prop. Line Reference	Depth at Pl	Lgth	House No. & Lot or Assess.No

Fig. 3.42. Building sewer location form

Also, since the part of the building sewer constructed in the street is generally buried prior to construction of the remaining part of the building sewer connecting a building to the completed sewer system, it is equally important to record the location and depth of the temporary end of the building sewer. This is usually done by measuring the distance from the end of the building sewer along the street property line to the nearest property corner and measuring the depth of the top of the end of the building sewer below the top of the curb (or surface of the ground if there is no curb). Also the end of the sewer should be located with respect to the curb line (how far inside or outside the curb and the depth from the top of the curb to the top of the sewer). These measurements also are entered onto a Building Sewer Location record. A long piece of wood (2 x 4) placed upright at the end of a temporary sewer is very helpful in the future when attempting to relocate the end of a buried sewer.

The wye, tee, and building sewer location data should be entered directly and immediately onto the forms provided.

3.674 "As-Built" Plans

At the start of a sewer construction project, the inspector should obtain two sets of the plans for the project and mark one copy "Working Plans" and the other set "As-Built" Plans. The working plans are used for on-the-job references and conferences.

The "as-built" plans are for the purpose of recording daily any constructed deviations from the line or depth of the sewer system facilities or any other deviation from the plans. Changes must be recorded as soon as they are found or completed and never put off to another day. Locations of building sewers are commonly shown on the "as-built" plans in addition to recording their location on a "Building Sewer Location Record."

REMEMBER:
"AS BUILT"
PLANS!

The actual location of the sewer system facilities are usually shown in red pencil on the "as-built" plans using the same scale and style of drafting and notation used in drafting the plans. The "as-built" plans should not be used in place of the inspector's working plans and should be kept clean and readable.

At the conclusion of the project, the "as-built" plans should be submitted to the project engineer in completed form. These plans are either filed directly as an "as-built" record of the project or used by a draftsman to revise the tracings from which the plans are printed. Copies of these plans must be sent to field workers as soon as possible because they must work from them.

The "as-built" plans also are used to prepare sewer location maps which are in turn used in conjunction with issuance of connection permits and subsequent maintenance of the sewer system.

3.7 TESTING OF PIPES

by George Freeland

3.71 Purpose of Testing

Air or water pressure can be used to test for leaks in the pipes of a wastewater collection system. Testing methods used depend on the types of conditions and the system being tested.

1. A new sewer having no service connections (stub-outs to property lines of future connections will have been plugged) is tested for leaks before being accepted from a contractor. In this case, the air test may include all of the pipe between two manholes in one single test.

2. A new sewer, or sewer system in service, is tested in small sections to determine where leaks exist.
3. A building sewer is tested because of suspected leaks.
4. An individual joint or length of pipe can be air tested using a television camera and a piece of equipment that can seal the pipe on both sides of the joint being tested.

The existence of leaks in a wastewater collection system is a serious and often expensive problem. For a pipe that is under a water table, infiltration will take place and continuously increase in the future. Pipes usually located above a water table can exfiltrate, causing raw wastewater to pollute soil and ground water. A health hazard is created when the wastewater reaches a water well or open ditches where children and pets play. Leaks in pipes also invite root intrusion and eventual severe problems and damage to a pipe system. The location and elimination of leaks in a new or existing wastewater collection system become one of the major concerns of any construction inspection or maintenance program.

The main reason for using low pressure air testing for testing sewers is that pressurized air exerts the same pressure in all directions during a specific instance in time. The fact that air can leak through a smaller crack than wastewater can be one of the drawbacks of the use of air testing. A properly conducted infiltration or exfiltration test using water will give a true reading of the quality of pipe construction. The problems with using the water test include the time, money and water wastage involved in running these tests. Extreme care must be exercised when specifying and conducting both air and water tests. In steep terrain, air tests are better than water tests because of excessive water pressures at the lower end of the sewer.

3.72 Air Testing

Each of the previously outlined four conditions can be tested using air testing (Figure 3.43 and 3.44) and is covered in this section with only the common applications that apply to all four being treated in the introduction.

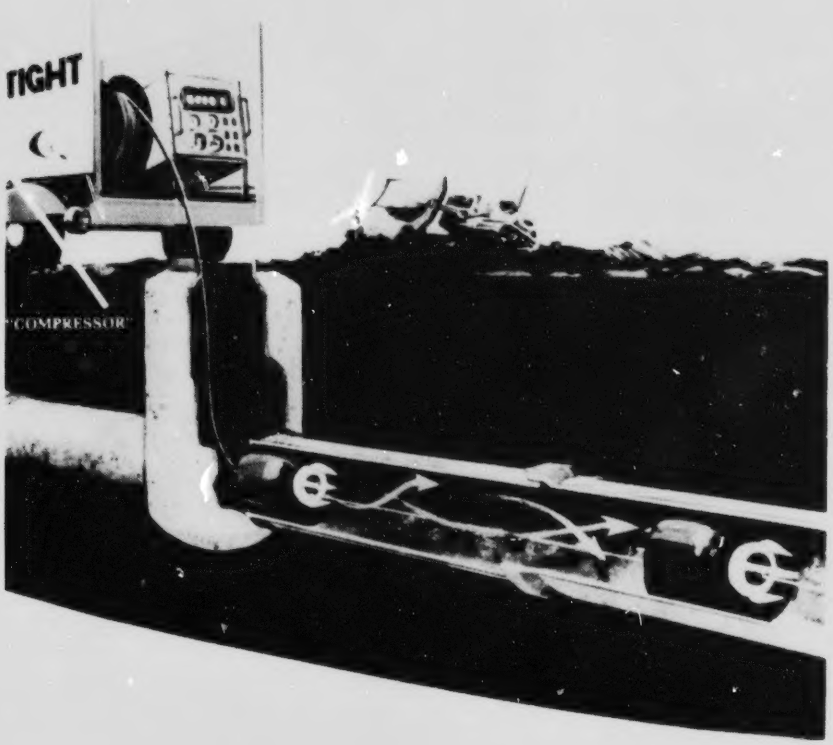
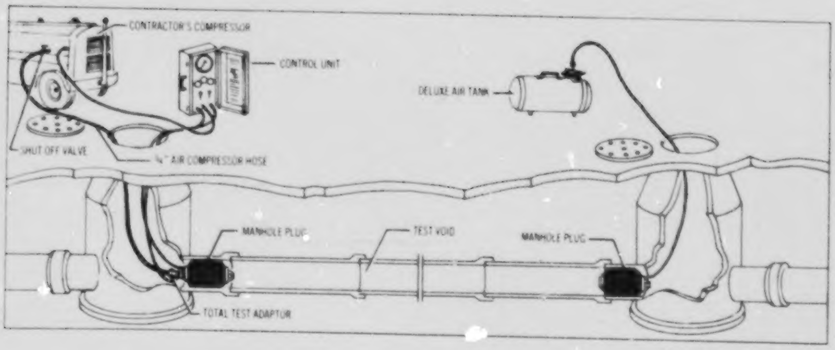
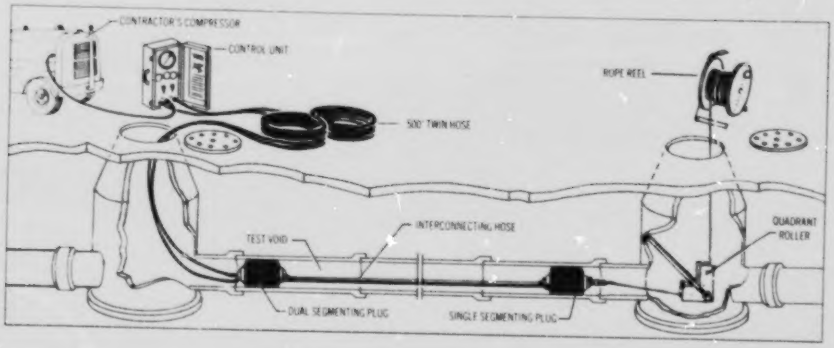

TIGHT
"COMPRESSOR"

Fig. 3.43. Air testing
(Courtesy of Cues)


CONTRACTOR'S COMPRESSOR
CONTROL UNIT
DELUXE AIR TANK
SHUT OFF VALVE
¾" AIR COMPRESSOR HOSE
MANHOLE PLUG
TEST VOID
MANHOLE PLUG
TOTAL TEST ADAPTOR

Manhole to manhole air test.


CONTRACTOR'S COMPRESSOR
CONTROL UNIT
ROPE REEL
500' TWIN HOSE
INTERCONNECTING HOSE
TEST VOID
QUADRANT ROLLER
DUAL SEGMENTING PLUG
SINGLE SEGMENTING PLUG

Segment of pipe air tests.

Fig. 3.44. Typical air test set ups

3.721 Air Pressure

Because air exerts equal pressure (in small confined spaces) in all directions and the pressure is easily increased or decreased, it is used to test for leaks in pipes and vessels. In testing wastewater collection systems, air is more likely to penetrate and to escape through small holes or hairline cracks than the wastewater carried by the pipe or the ground water that may enter from the outside of the pipe. For this reason, air testing is replacing the older and less dependable hydraulic or water pressure testing of wastewater collection systems in many regions. Some authorities no longer accept the results of water tests for pipe leaks.

1. When using air to test for leaks in sewers, the air pressure inside the sewer is the same as the surrounding or ambient[17] air pressure. This pressure is often called atmospheric pressure. During the air test, a compressor pumps air into the sewer and increases the air pressure inside the sewer. This higher pressure (above atmospheric pressure) is measured with a pressure gage. If leaks are present in the sewer, the air pressure in the sewer will go back down to atmospheric pressure.

2. Two types of pressure gages are in general use for measuring air pressures, the Bourdon tube and the diaphragm type.

   a. Bourdon tube types are the ones usually applied to pressures from around 10 psi and up to 10,000 psi. The accuracy of this type of gage is not critical and these gages are used for welding gas gages where an error of as much as two or three pounds per square inch will not be serious.

   b. Diaphragm type gages, also called aneroid gages, are limited to measuring pressure differences of under 30 psi (except for specially manufactured gages) and are much more accurate throughout their full range.

---

[17] Ambient (AM-bee-ent). Surrounding.

200

c. Both Bourdon tube and diaphragm gages can have logarithmic scales[18] for easier and more sensitive readings at lower pressure values.

3. Test pressures for wastewater collection systems are seldom over 10 psi and a diaphragm type of pressure gage with a logarithmic scale is considered the best type.

3.722 Test Pressures

Sewer pipes are usually tested at air pressures around 3 to 5 psi above any outside water pressure on the pipe. This outside pressure, which may be caused by ground water levels that are higher than the pipe, must be known or estimated. Therefore, the air pressure inside the pipe must be great enough to overcome the water pressure outside the pipe so the air can leak out if there are cracks and holes in the pipe. Be careful air test pressures are not too high, because they could blow out pipe joints.

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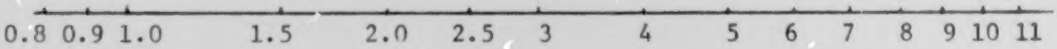
[18] Logarithmic scales. (LOG-arith-mick) A logarithmic scale has the numbers getting smaller as the distances between the numbers increases.



Where a water table elevation is known and the depth of the pipe below this water table can be measured, determine the test pressure by adding one-half pound per square inch for each foot of water depth above the bottom of the pipe to the test pressure.

?
8FT DEEP
5 PSI
1/2 LBS OR
4 PSI
T.P.=

> EXAMPLE: A pipe is known to have an average depth of two feet below the existing water table of the ground water and is to be tested to a pressure of 3 psi. If we increase the test pressure one half pound for each foot of water above it, or an additional 1 psi, the test pressure for the pipe will be 4 psi.

3.723 Volume of Air Required

Further along in section 3.73, where each method of air testing is covered in detail, required equipment is listed. In all cases, a source of air pressure is required and this is usually provided by an air compressor. An adequate capacity air compressor should be on hand before starting to pressurize a pipeline. Tables 3.2 and 3.3 can provide an estimate of the amount of air required for selected pipe sizes and required test pressures.

TABLE 3.2. PIPE SIZES AND VOLUMES

Diameter, Inches	Volume, cu ft per ft of pipe	
4	0.087	
6	0.196	(1)*
8	0.349	
10	0.545	
12	0.785	
15	1.23	
18	1.77	
21	2.41	
24	3.14	
27	3.98	
30	4.91	
36	7.07	(2)*
42	9.62	
48	12.57	
54	15.90	
60	19.64	

*Number of example problems on following pages.

TABLE 3.3. PRESSURE, ATMOSPHERES AND DEPTHS

Test, PSI*	Atmosphere Increase	Water Depth Over Pipe, ft	
4	0.2666	0	
5	0.3333	2	
6	0.4	4	(1)
7	0.4666	6	(2)
8	0.5333	8	
9	0.6	10	
10	0.6666	12	
11	0.7333	14	
12	0.8	16	
13	0.8666	18	
14	0.9333	20	
15	1.0	22	
16	1.0666	24	
17	1.1333	26	
18	1.2	28	
19	1.2666	30	
20	1.3333	32	

*NOTE: For safety reasons, test pressures should not exceed 6 psi. If there is over 4 feet of water depth over a pipe and water is not leaking into the sewer, the pipe apparently will not have problems from infiltration or exfiltration.

First determine the pipe diameter and length of the pipe to be tested. Table 3.2 shows the volume of air in one foot of length of a pipe with the inside diameter indicated. Table 3.3 shows how much additional air in atmospheres (remember one atmosphere is approximately 15 psi absolute pressure) must be added to any space to achieve the indicated test pressure. The third column indicates the approximate depth of the pipe in feet below the elevation of the ground water table. The following examples show how to determine air volumes and pressures.

> EXAMPLE: 350 feet of new 6-inch pipe is four feet below the water table and is to be given an air test.
>
> From Table 3.2, 6-inch pipe has a volume of .196 cubic feet per foot of length. Multiply this value by the total length to be tested at one time to get the total volume of the pipe.
>
> $$\begin{aligned}\text{Pipe Volume, cu ft} &= (\text{Table 3.2 value})(\text{Length, ft})\\ &= (0.196 \text{ cu ft/ft})(350 \text{ ft})\\ &= 68.6 \text{ cu ft}\end{aligned}$$
>
> For an effective 4 psi test with the pipe 4 feet below the elevation of the water table, we will need the 4 psi plus a half pound for each foot of depth, or 2 psi more. This means that our test pressure will be 6 psi (4 psi + 2 psi). For 6 psi, we have to add 0.40 atmospheres to the air that is already in the pipe, or the compressor will have to put 40 percent of the volume of the pipe into the test area.
>
> $$\begin{aligned}\text{Volume of test air, cu ft} &= (\text{Pipe Volume, cu ft})(\text{Table 3.3 Value})\\ &= (68.6 \text{ cu ft})(0.40)\\ &= 27.44 \text{ cu ft}\end{aligned}$$
>
> From this information, a 2 CFM[19] at 75 psi compressor will take about three minutes to pressurize the length of pipe to the desired 5 psi. To determine how long a compressor will take to fill a pipe with air to the desired pressure,

---

[19] CFM. Cubic Feet per Minute.

consult the compressor's operation and maintenance manual prepared by the manufacturer. If the difference in temperature between the air pumped into the pipe and the soil surrounding the pipe is large, consideration may have to be given to this factor when estimating the time it will take to fill the pipe with air. The restrictions or constrictions in the air line and the length of air line between the compressor and the plug often cause sufficient friction losses to significantly increase the time required to pressurize the line being tested.

EXAMPLE 2: 500 feet of 36-inch pipe is 6 feet below the water table and is to be given an air test.

Table 3.2 shows 7.07 cubic feet per foot volume for a 36-inch pipe and the length is 500 feet.

$$\begin{aligned}\text{Pipe Volume, cu ft} &= (\text{Table 3.2 Value})(\text{Length, ft}) \\ &= (7.07\text{ cu ft/ft})(500\text{ ft}) \\ &= 3{,}535\text{ cu ft}\end{aligned}$$

Table 3.3 shows that at 6 feet below the water table, test pressure is 7 psi.

$$\begin{aligned}\text{Volume of test} & \\ \text{air, cu ft} &= (\text{Pipe Volume, cu ft})(\text{Table 3.3 Value}) \\ &= (3{,}535\text{ cu ft})(0.467) \\ &= 1{,}641\text{ cu ft}\end{aligned}$$

In this case, the little 2 CFM at 75 psi compressor would take over two and one-half hours to pressurize the pipe to the desired test pressure. A larger compressor is obviously needed to decrease the time required to reach the required test pressure. If there were any leaks in the pipe being tested, the little compressor may never produce any pressure in the pipe.

3.73 Air Testing Procedures

3.731 Long Pipe Runs - Manhole to Manhole

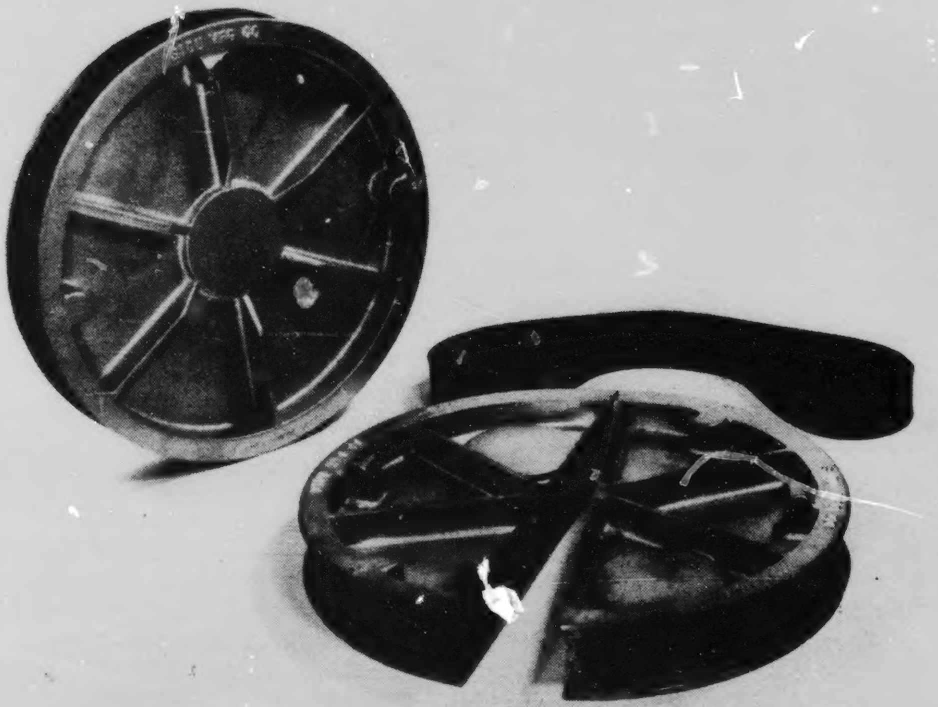
Testing long lengths of pipe is usually limited to new wastewater collection systems that have no service connections, or to inspect pipes that should never have service connections or branches connected to them outside of a manhole.

1. Equipment needed:

   a. Two pipe plugs (Figures 3.45 and 3.46) with taps for connection of pressure gages and air hose. For pipes up to 24-inches in diameter, these may be either mechanical plugs with rubber gaskets or inflatable plugs with rubber boots. For larger than 24-inch pipes, the plugs must either be inflatable bag stoppers or made in two or more pieces in order to be easily positioned in the pipes.

   b. An air compressor of required capacity with hose to connect to pipe plug. There should be a shut-off valve on the hose connection to the plug. ALL GAGES AND VALVES MUST BE OUTSIDE THE MANHOLE TO AVOID INJURY TO ANYONE READING GAGES OR ADJUSTING VALVES IF A PLUG SHOULD BE BLOWN OUT OF THE PIPE.

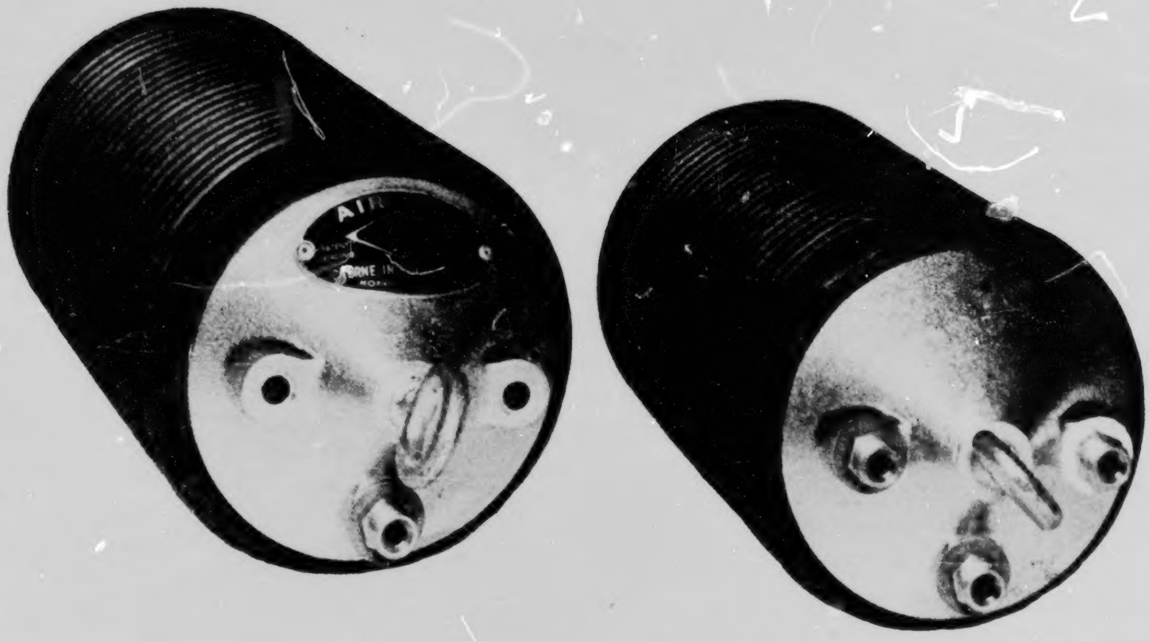
   c. A pressure gage should be in the line between the shut-off valve and the pipe plug to indicate pressure behind the plug. THIS GAGE MUST BE OUT OF THE MANHOLE.



May be used plain (as a plug) or drilled and tapped for air testing.

Fig. 3.45. Air plug

(Courtesy of Sidu Manufacturing Company)



Used for: 1. Isolating leaks
2. Air testing between manholes
3. Plug for maintenance and repair

Fig. 3.46. Air plugs
(Courtesy of Cherne)

   d. A watch to indicate length of test in minutes and seconds is desirable where specified tests are to be made.

   e. A garden spray that can be filled with soap water with a long pipe wand so the operator can spray the plug from outside the manhole.

2. Manpower should be not less than three persons. Where the air compressor does not have an automatic shut-off, one man will have to stand by to shut it down at the start of the test period.

3. Test procedure.

   a. Before testing a sewer, test your equipment. A good procedure is to carry on the equipment truck four-foot sections of PVC pipe of the sizes commonly air tested in the field. Insert a plug in each end of the PVC pipe of the diameter to be air tested and test the air-test equipment. This procedure assures you that your plugs, hoses, gages and equipment are working properly. Record these results so the accuracy of your equipment can't be questioned when performing actual field tests.

   b. Plugs are inserted at each end of the pipe and expanded and secured. Any debris, such as sand or dirt, must be carefully removed from the pipe locations where the gaskets or rubber boots are to make a seal. Do not smear a heavy grease over the outer faces of the gaskets or boots to increase their capacity to seal against any uneven or rough surfaces on the inside of the pipe. The grease will reduce the capability of the plug to maintain its position. Even with proper bracing, air can by-pass a greased plug.

   c. Before any air hose is connected to the plug at either end of the pipe, the plugs are firmly blocked and wedged into place so that they cannot be pushed or blown out. To understand the need for precaution, realize that the force trying to push the plugs out is equal to the pressure (psi) times the plug surface area (sq in). Table 3.4 gives plugs surface areas in square inches.

TABLE 3.4. PLUG SURFACE AREAS

Pipe Diameter, Inches	Surface Areas, Square Inches*	If Pressure 5 psi, Force Against Plug, lbs**
4	12.56	63
6	28.27	141
8	50.26	251
10	78.54	393
12	113.10	566
15	176.70	884
18	254.47	1,272
21	346.36	1,732
24	452.39	2,262
30	706.86	3,534
36	1,017.87	5,089
42	1,385.45	6,927
48	1,809.56	9,048
54	2,290.23	11,451
60	2,827.44	14,137

* To calculate surface area, sq in = $\frac{\pi}{4}$ (Diameter, in)^2

** To calculate force, lbs = (Area, sq in)(Pressure, lbs/sq in)

EXAMPLE 3. Determine the force against each plug in Example 2. The pipe diameter is 36-inches and the test pressure is 7 psi.

Known	Unknown
Pipe Diameter, in = 36 in Test Pressure, psi = 7 psi Surface Area, sq in = 1,017.87 sq in	Force, lbs

Determine force against plug

Force, lbs = (Test Pressure, psi)(Surface Area, sq in)

= (7 lbs/sq in)(1,017.87 sq in)

= 7,125 pounds

How would you like to be clobbered by a force of 7,125 pounds?

CAUTION

NEVER ALLOW ANY PERSON TO ENTER A MANHOLE WHILE AIR IS BEING FORCED INTO A PIPE WITH PLUGS IN PLACE OR WHEN ANY PRESSURE REMAINS BEHIND PLUGS.

Realizing the heavy forces that are exerted against the plugs by the pressures they are required to withstand, adequate timbers and other bracing material must be selected with care and properly placed so that there is no possible way for the plug to work loose.

The plugs are inflated and the air pressure within the plug helps to seal the plug against the pipe walls to hold the plug in place and to prevent air from leaking out around the plug.

d. After plugs are in place, the air hose is connected, the plugs are inflated or sealed, and then the sewer is pressurized to the test pressure.

e. Supply air slowly to the section of sewer system being tested until the internal pressure is raised to 4.0 (or any other test pressure) pounds per square inch gage pressure (psig). Be careful and do not raise the air pressure much higher than 4.0 psig above the pressure outside the pipeline because it is possible to rupture pipe joints with excessive air pressure. When the test air pressure is reached, close the isolation valve and start the test.

f. After an internal pressure of 4.0 psig is obtained, allow at least two minutes for air temperature to stabilize, adding only the amount of air required to maintain the 4.0 psig.

g. After two minutes, disconnect the air supply and when the air pressure in the sewer system has decreased to 3.5 psig, start a "stop watch" and stop it when the pressure decreases to 2.5 psig.

h. Compute the allowable time for a decrease in pressure from 3.5 to 2.5 psig using the following formulas:

$$tQ = \frac{0.022}{Q}\left(d_1^2L_1 + d_2^2L_2 + d_n^2L_n\right)$$

$$tq = \frac{0.085}{q}\left(\frac{d_1^2L_1 + d_2^2L_2 + d_n^2L_n}{d_1L_1 + d_2L_2 + d_nL_n}\right)$$

Where: tQ = allowable time for decrease in pressure from 3.5 to 2.5 psig in seconds.

tq = Same.

Q = 2.0 cubic feet per minute of air loss.

q = 0.0030 cubic feet per minute of air loss per square foot of internal pipe surface.

d = diameter in inches of sewer pipe in section of system being tested.

L = length of sewer pipe being tested.

i. Compare measured time for the air pressure to decrease from 3.5 to 2.5 psig and if it is greater than the lesser of the two allowable times computed from the formulas, the section of sewer system has passed the air test. Experience indicates that infiltration of ground water into the section of a sewer system passing the low pressure air test will be less than 200 gallons per day per inch of pipe diameter per mile of sewer.

For example, assume an air test is conducted on a section of a sewer system containing 400 feet of 8-inch diameter main sewer line and 360 feet of 4-inch diameter building sewer line and the measured time for the air pressure to decrease from 3.5 to 2.5 psig is 225 seconds. Does the section of the collection system pass the air test?

$$tQ = \frac{0.022}{Q}\left(d_1^2L_1 + d_2^2L_2\right)$$

$$= \frac{0.022}{2}\left(8^2 \times 400 + 4^2 \times 360\right)$$

$$= 0.011\ (25{,}600 + 5{,}760)$$

$$= \underline{\underline{345 \text{ seconds}}}$$

$$tq = \frac{0.085}{q}\left(\frac{d_1^2L_1 + d_2^2L_2}{d_1L_1 + d_2L_2}\right)$$

$$= \frac{0.085}{0.0030}\left(\frac{8^2 \times 400 + 4^2 \times 360}{8 \times 400 + 4 \times 360}\right)$$

$$= 28.33\ \left(\frac{25{,}600 + 5{,}760}{3{,}200 + 1{,}440}\right)$$

$$= \underline{\underline{192 \text{ seconds}}}$$

Since the measured time of 225 seconds is greater than the lesser of the allowable times (192 seconds), the section of the collection system passes the air test.

If you do considerable air testing, tables indicating allowable air losses or times for pressures to drop will be most helpful.

j. If the test fails, there is a chance that one or both of the seals made by the plugs may be defective. To determine if this is a fact, the pressure in the test area is released completely. A person using a garden spray full of soapy water with a long pipe wand can spray the plug from outside the manhole. Apply liberal amounts of the soap suds to the seats and connections of the plugs. Be sure the bracing against the test plugs is secure. Repressurize the test section slightly. Inspect for leaks. Be sure to keep out of the way of the plug if it should break loose. If the

gaskets or boots are not properly seated and leak-tight against the pipe wall, the area is depressurized and the plugs re-seated. This test is continued until an air-tight seal is achieved.

k. When the air test is completed, the pressure in the test section is lowered before deflating either of the pipe plugs.

CAUTION

NEVER REMOVE BRACING OR CRIBBING FROM BEHIND A TEST PLUG UNTIL PRESSURES ON BOTH SIDES OF IT ARE EQUALIZED AND RELEASE VALVES ARE FULLY OPEN.

l. Once the test section has lost its air pressure, the bracing or cribbing may be removed and the plugs taken out.

3.732 Search for Specific Leaks

Where a pipe is known to have leaks, or where a pipe in service is connected to building drains, these small sections are tested with remote inflation plugs. In this operation, two inflatable plugs of special design are attached to each other with a specific length of chain or steel cable (Fig. 3.44). The plugs are pulled through the pipe with hand winches and stopped at each section equal to the distance between them for a test of the isolated pipe section.

1. Equipment required for this type of testing will include all of the following:

   a. An air compressor of adequate size, but usually not as large as that required for testing long lengths of pipe.

   b. An air pressure control console. This console must have two air pressure regulators, one for controlling the inflation pressures of the boots of the two plugs and one for controlling the test pressure to be injected between them. The control console must also have valving to:

1. Inject or release the air pressure in the plug boots to isolate the section of pipe being tested.

2. Inject air pressure into the space in the pipes between the plugs.

3. Isolate the area between the plugs with a pressure gage showing this pressure and indicating any changes in it over a specified time period.

4. Release the pressure between the two plugs and then the plug pressure before moving to a new test section or removing the plugs from the sewer.

c. Two plugs with inflation boots that are properly sized for the pipe to be tested. One of these plugs must have at least one through plug air attachment.

d. Three air hoses are generally used for greater speed, but two may be sufficient. One hose is used to inflate the boots of the plugs and the other hose is used to inject air to develop the test pressure between the plugs. A third hose may be used to measure the pressure in the test space between the plugs and to release the test pressure through a valve when the test at that location in the pipe is completed.

e. Two winches to pull the plugs and hoses through the pipe to be tested.

f. A distance marker system, usually a spring clamp and two stakes or marks on the pavement.

g. An accurate map or diagram of the sewer to be tested, showing footages of connections to the line.

2. Manpower requirements are at least two persons plus support crew to direct traffic or provide other necessary assistance. One person operates the control console and records the test results. The second person moves the plugs with the winch each time a test is completed. A third person must be available whenever anyone must enter a manhole.

3. Prior to the testing of any pipe by this method, the pipe should be thoroughly cleaned to remove any sand, silt, or other debris which may prevent the inflatable plugs from making a good seal against the pipe wall. The use of a high velocity cleaner[20] in pipes up to 15 inches in diameter may be adequate. Balling[20] should be done in larger lines which are not properly or easily cleaned with the high velocity water cleaner. If necessary, the line should be cleaned with a rodding machine[20] or ball to make certain that there are no obstructions which would not permit passage of the two plugs. Old sewers or sewers with a history of stoppages should be inspected by closed circuit television (Chapter 4) after they have been cleaned to be certain that there are no obstructions that may prevent the movement of the air test plugs.

4. In operation, the plugs are put into the line and pulled until the rear plug is just inside of the pipe at the starting manhole.

   a. The plugs are then inflated to isolate the pipe area between them.

   b. The desired test pressure is then injected into the area. The pressure gage measures the pressure between the plugs. Pressures used for testing should generally conform to those listed in Table 3.3.

---

[20] Chapter 5. Pipeline Cleaning and Maintenance Methods, describes these pieces of equipment and how to use them.

c. The length of the test should be established on the basis of one minute plus one second for each cubic foot of space between the two plugs.

d. When a leak is detected, there is a possibility that one of the boots is not seated properly. To attempt to remove an object or bit of debris which may obstruct the boot's contact with the pipe wall, deflate boots while there is pressure between them. This may tend to blow debris out of the area of boot contact. Be extremely careful that no one will be hit by flying debris. Also be sure there is no slack in the line between the boots or the boots could be severely damaged.

e. Retest the same area. If a leak is still detected, record the fact and the rate of leakage as 'slow', 'moderate', or 'rapid'. Records must include the pressure drop per minute, diameter of pipe, length of pipe, location and date tested.

f. The plugs are ready to be moved to the next test section after they are deflated.

5. Keeping a good record of footages is extremely important in this type of operation. Each test location and the results must be properly and accurately recorded.

   a. The distance between the two test plugs should be established and firmly fixed before starting the test. This distance is measured from the inside sealing surfaces or the inside end of one plug to the inside end of the other.

   b. To test a section of pipe, the crew leader should review the available information on the pipe to be tested so as to select the areas to be tested and to determine the length of each test section. The inside distance between plugs is usually set at 3-feet, 6-feet, or 9-feet plus three to six inches, depending on the distance between joints and the number of joints to be tested each time. When moving the plugs through the pipe, each move should be exactly the distance between the plugs or a little less.

c. To select the distance between the plugs before starting the run, the superintendent should estimate whether the pipe to be tested may have many bad leaks or joints, or if only three or four problem areas are suspected. If every joint is suspected as the location of a possible leak, the distance should be limited to only one pipe section or less and only one joint should be tested at a time. Where only a few, if any, joints are expected to be bad, the distance can be increased with proper coupling, any desired distance up to the distance between manholes could be used. Plugs can be connected and pulled through sewers by the use of a chain or cable which is safer than using rods.

d. Where a leak is detected by a pressure drop and more than one pipe joint is being tested, the plugs are deflated and pulled back a distance of one pipe section and the test repeated. If the leak is still between the plugs, they are deflated and moved back another pipe section length and the test made again. When the leak is lost, the distance to the leak point or joint is then known, because it is the next joint beyond the lead plug.

e. The distance measurement must be maintained by the worker at the pull winch. If the plug assembly must be backed up at any time, do not move the clip on the pull cable until the test of the leak area is completed. The worker may then pull the plugs to their original position, move the clip back to relocate the plugs in the next part to be tested and then pull them into their new position.

In event there is a question about the accuracy of the footage, the lead plug can be used to find the connection to the line being tested. This is done by moving the plug assembly in one-foot increments and testing after each re-location, usually done when the footage record shows the connection would be located in the next test area. When the test area cannot be pressurized, the lead plug will be within one foot of and beyond the connection.

6. The operator at the control console must always be alert to any pressure drop in the plug boots that might indicate boot perforation or leakage. When this occurs, and a boot is damaged by some object in the pipe, it must be immediately removed and repaired or replaced. Never try to test using this method with defective boots.

7. When one of the connections to the pipe run being tested is between the plugs, the void area (space in pipe between plugs) cannot be pressurized unless the connection is blocked with another plug. The pull winch man, who is maintaining a record of the footages test, should be aware of the occurrence of one of the connections ahead of arrival and signal the test equipment operator.

8. Test records and rough footage records are usually maintained on the map with pencil marks and footage totals.

3.733 Building Sewers

There are several ways that building sewers can be tested. The selection of any method will depend greatly on the conditions which might be encountered. The paragraphs that follow briefly outline the selection of a method and the proper procedures.

1. Where a building sewer is in a straight line, two inflatable plugs are used, one of which is attached to rigid coupled sewer rods so that it may be pushed down the pipe with a hose for inflation at or close to the connection to the lateral sewer. The second plug will have a pressure gage and a connection for air to be passed through it from another hose.

a. If adequate clean outs are available, the first plug is attached to the rods and pushed into the pipe to the main or to any desired test distance. The last section of the rod is disconnected so that the rod is just inside of the clean out far enough to install the second plug. The far plug is then inflated and the hose, with closed valve, is pushed into the pipe just far enough to permit insertion of the second plug.

b. The second plug, which may be a mechanical type of plug, is then put into the entrance of the pipe and secured. The space between the plugs is then pressurized for an air test.

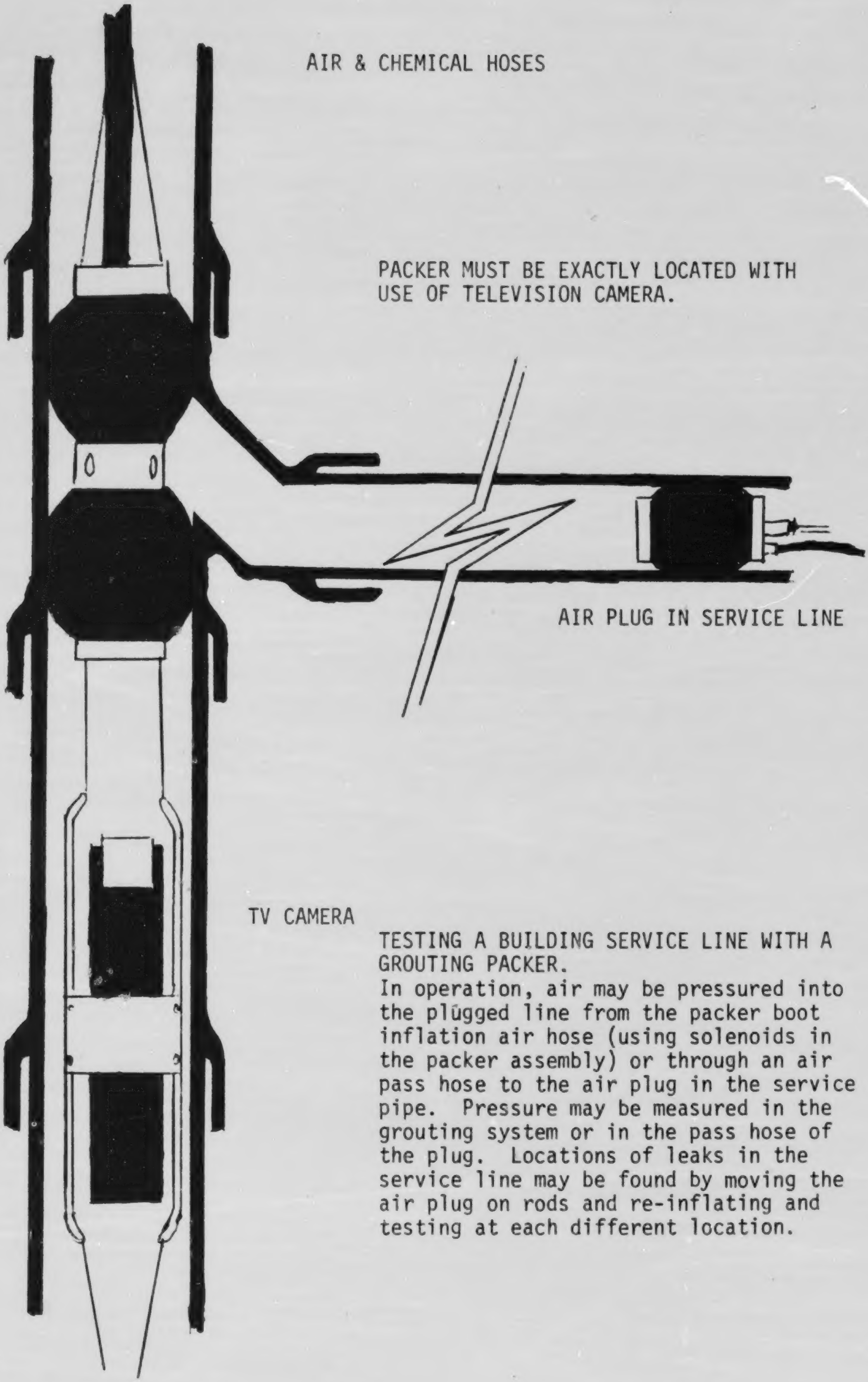
c. If the test fails, indicating a leak in the pipe section being tested, the far plug may be pulled back a short distance and re-inflated. This procedure is repeated at short distances until no leakage is indicated. When this happens, it indicates that the far plug has been pulled far enough back and beyond the point of leakage, thus locating the approximate area of the leak.

d. In the event a usable clean out is not available, the pipe may be excavated and opened for test purposes where desired. A usable clean out is one which will permit the section of pipe to be tested to be isolated from the building sewer system and its vents and traps.

2. In some testing of this type, two inflatable plugs are connected with one or more rods and pushed into the pipe section. Once in position, they are used in much the same manner as the two inflatable plugs are used in testing 6-inch or larger pipes, with rods being used to relocate the plugs for each test.

3. Where a pipeline pressure grouting unit which has an air testing capacity is available, it can be used for individual pipe joint air testing in conjunction with the television camera (Figure 3.47). Footage and recording of test results will depend upon the systems included with the television and grouting equipment.

   a. Where a pressure grouting packer (Fig. 3.47) is equipped for air testing of joints, the manufacturer of the equipment should provide detailed instructions.


AIR & CHEMICAL HOSES
PACKER MUST BE EXACTLY LOCATED WITH USE OF TELEVISION CAMERA.
AIR PLUG IN SERVICE LINE
TV CAMERA

TESTING A BUILDING SERVICE LINE WITH A GROUTING PACKER.

In operation, air may be pressured into the plugged line from the packer boot inflation air hose (using solenoids in the packer assembly) or through an air pass hose to the air plug in the service pipe. Pressure may be measured in the grouting system or in the pass hose of the plug. Locations of leaks in the service line may be found by moving the air plug on rods and re-inflating and testing at each different location.

Fig. 3.47. Air testing with TV camera

b. The use of one or the other of the two sealing chemical solutions being forced against the joint by air or pump pressure may not have the same results as a direct air test on the joint.

3.74 Purpose of Water Testing

For many years, wastewater collection systems were tested for leaks by filling the pipes with water and allowing the system to stand overnight with a head of water pressure above the water in the pipe. In most cases, this test was made before the pipe had been buried and was still exposed. While generally discontinued in the last few years due to the imperfect results of such tests, there are some situations and areas where it is still applicable.

Water testing will obviously be limited to new or old sewers where no services have been connected and where the full length between two manholes may be tested at one time. Any application of water testing to small sections between two plugs similar to air testing is not considered economically nor practically useful for locating leaks.

3.75 Early Procedure

1. The pre-backfill method of pipe joint testing required the downstream end of the pipe to be plugged in the same way as for air testing as previously outlined. The entrances to the upstream manhole usually were plugged too.

2. The pipe was then filled with water and the manhole filled to provide up to four pounds of head pressure at the lower end of the pipe.

3. If the pipe was still exposed, an inspector walked its length, inspecting each joint as he came to it and generally observing all other parts for any signs of water leaks. Such a test obviously required that the weather be dry for several days prior to the test, and that the bottom of the pipe trench be an adequate distance above the water table elevation.

3.76 Current Procedure

Water tests (Fig. 3.48) can be used to test sewers after the trench has been backfilled and compacted because the sewer or the joint may be damaged during these operations. Since leakage cannot be observed visually, the amount of leakage in the test section is determined by measuring the rate at which the water surface in the manhole falls. The procedure for water testing is as follows:

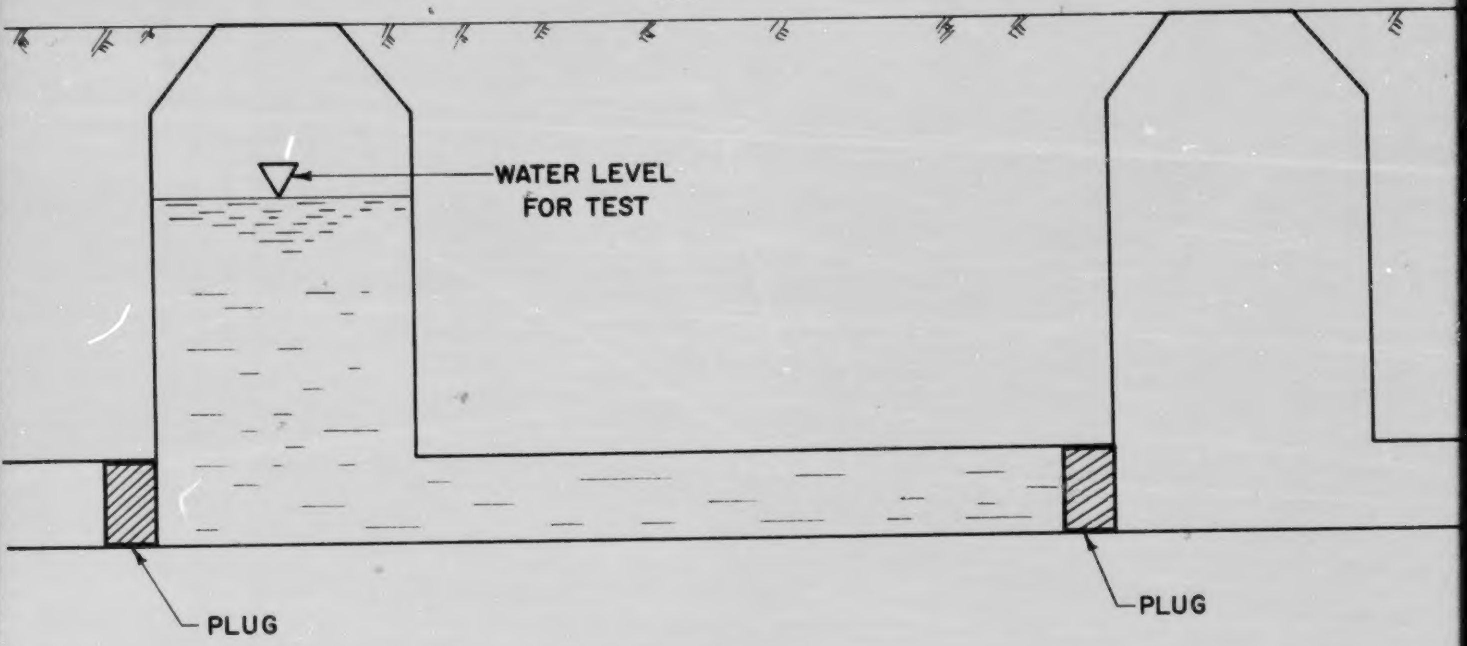

WATER LEVEL
FOR TEST
PLUG
PLUG

Fig. 3.48. Water testing

1. The pipe to be tested is plugged as in the air test, with plugs isolating a sewer section between two manholes. Instead of using air, the section to be tested is filled with water.

2. The section of pipe is filled with water and the level of water in the manhole is recorded. Allow some time for the pipe material to become saturated.

3. The level of the water in the manhole is marked and recorded and the section being tested is left alone overnight. If the water level shows an appreciable drop during the test period, a leak is indicated. By measuring the drop in the manhole, the volume of water leaked can be calculated. Be sure to include all manholes that are used in the test section to figure volume of lost water. See Appendix M, Applications of Arithmetic to Collection Systems, Section M.9 E, Leak Test, for details on how to calculate the volume leaked and the rate of leakage.

3.77 Considerations for Water Testing

Water testing of pipes originated when the methods of sealing pipe joints employed such materials as oakum, pitch, and concrete grout. The purpose of water testing was to determine that the entire circumference of a pipe joint had been properly constructed and that there were no gaps or poor quality workmanship places in the joint.

Because it was most applicable to testing the pipe prior to backfill, it served to certify to proper construction up to that point. The reason this type of testing and inspection has given many systems good results over the years is mostly attributable to the use of hand tools which were exclusively used for backfill and compaction. If the modern compaction devices, such as hydro-tampers, were used on the older lines, almost all of them would have had severe damage and shorter lifespans than they have demonstrated.

Except for small service laterals and similar types of pipe construction, the use of a water test is considered to be obsolete. Accurate results for water testing are difficult to achieve. Under most circumstances air testing provides quicker, more accurate and more economical test results.

3.8 ADDITIONAL READING

a. "Design and Construction of Sanitary and Storm Sewers," MOP-9, Water Pollution Control Federation, 2626 Pennsylvania Avenue, N.W., Washington, D. C. 20037. Price $5.00 to members; $10.00 to others. Indicate your member association when ordering.

b. "Public Works Inspectors' Manual," Silas R. Birch, Jr., published by Building News, Inc., 3055 Overland Avenue, Los Angeles, CA 90034. Price $6.50.

c. "Safety and Health in Excavation and Trenching Operations," a resource supplement of OSHA 2092 by Occupational Health and Safety Administration, U.S. Department of Labor. Entire kit of 139 slides and two books cost $21.00. Order from USA General Services Administration, National Archives and Records Service, Audio Visual Center, Sales Branch, Washington, D. C. 20409.

d. "Experience in Using the Low-Pressure Air Test for Sanitary Sewers," by Roy Edwin Ramseier and George Charles Riek, Journal Water Pollution Control Federation, Vol. 38, No. 10, October 1966, pp. 1623-1633.

e. "Air Testing Sanitary Sewers," by Sam H. Hobbs and Lloyd G. Cherne, Journal Water Pollution Control Federation, Vol. 40, No. 4, April 1968, pp. 636-642.

f. "Testing New Sewer Pipe Installations," by Roy E. Ramseier, Journal Water Pollution Control Federation, Vol. 44, No. 4, April 1972, pp. 557-564.

CHAPTER 4

SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

by

George Freeland

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by George Freeland

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OBJECTIVES

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

After completion of Chapter 4 you should be able to do the following:

1. Inspect new sewers and replacement sewers for installation as planned by examining line and grade, joint and junction adequacy, and proper installation of manholes and appurtenances.
2. Test for leaks in joints, taps, sewers and manholes of existing facilities.
3. Find legal, illegal, unauthorized and improper connections.
4. Locate and determine the seriousness of inflow, infiltration, exfiltration and diversion flow problems.
5. Identify and evaluate damage due to corrosion, cracking, crushing, subsidence (soil settling), root intrusion, stoppages, washouts and improper connections.
6. Provide meaningful reports to supervisors so they can assign priorities in order to develop cost-effective maintenance or corrective action programs.
7. Safely enter and leave manholes and other confined spaces.
8. Effectively use the inspecting and testing tools and procedures described in this chapter including closed circuit television, smoke testing, dye testing and pipeline lamping.

GLOSSARY

FAIR LEAD PULLEY FAIR LEAD PULLEY

Pulley placed in manhole to guide TV camera, electric cables, and pull cable into sewer.

FLOAT LINE FLOAT LINE

A length of rope or heavy twine attached to a float, plastic jug or parachute to be carried by the flow in a sewer from one manhole to the next.

HERTZ (HURTS) HERTZ

Number of complete electromagnetic cycles or waves in one second of an electrical or electronic circuit. Also called the frequency of the current. Abbreviated Hz.

LAMPING LAMPING

Using reflected sunlight or a powerful light beam to inspect a sewer between two adjacent manholes. The light is directed down the pipe from one manhole. If it can be seen from the next manhole, it indicates that the line is open and straight.

OLFACTORY FATIGUE (ol-FACTORY) OLFACTORY FATIGUE

When our nose becomes tired of or accustomed to smelling a particular odor and can no longer detect the presence of the odor.

SEWER GAS SEWER GAS

(1) Gas evolved in collection lines (sewers) that results from the decomposition of organic matter in the wastewater. When testing for gases found in sewers, test for lack of oxygen and also for explosive and toxic gases.

(2) Any gas present in the wastewater collection system, even though it is from such sources as gas mains, gasoline and cleaning fluid.

SADDLE CONNECTION

SADDLE CONNECTION

A building service connection made to a sewer main with a device called a saddle. This device makes a tight seal against the main pipe by use of a clamp, adhesive, or gasket and prevents the service pipe from protruding into the main.

SURCHARGE

SURCHARGE

Sewers are surcharged when the surface of the wastewater in manholes is above the top of the sewer pipe. The sewer is under pressure or a head, rather than at atmospheric pressure.

TAG LINE

TAG LINE

A line, rope or cable that follows equipment through a sewer so the equipment can be pulled back out if it encounters an obstruction or becomes stuck. Equipment is pulled forward with a pull line.

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 1 of 5 Lessons)

4.0 REASONS FOR INSPECTING AND TESTING

Wastewater collection systems are intended to be a reliable method of conveying wastewater from individual dischargers to wastewater treatment plants. Inspection and testing are the techniques used to gather information to develop operation and maintenance programs to insure that new and existing collection systems serve their intended purposes on a continuing basis. Inspection and testing are necessary to do the following:

1. Identify existing or potential problem areas in the collection system,
2. Evaluate seriousness of detected problems,
3. Locate the position of problems, and
4. Provide clear, concise, and meaningful reports to supervisors regarding problems.

Two major purposes of inspecting and testing are to prevent leaks in the wastewater collection system from developing and to identify existing leaks so they can be corrected. The existence of leaks in a wastewater collection system is a serious and often expensive problem. When a sewer is under a water table, infiltration can take place and occupy valuable capacity in the sewer and the downstream treatment plant. Sewers located above a water table can exfiltrate, allowing raw wastewater to pollute soil and ground water. A health hazard is created when the wastewater reaches a nearby well or open ditches where children and pets play. Leaks in sewers also invite root intrusion which eventually can cause stoppages, damage to the sewer and infiltration or exfiltration depending on the elevation of the water table. The location and elimination of leaks in a wastewater collection system is one of the major concerns of wastewater collection system workers and their supervisors.

QUESTIONS

4.0A Why should wastewater collection systems be inspected and tested?

4.0B Why are leaks a problem in wastewater collection systems?

4.1 TRAFFIC AND MANHOLE SAFETY

Before inspecting, testing, cleaning or repairing sewers or manholes located in streets or freeways, you must safely

1. Drive to the job site,
2. Park vehicles,
3. Route traffic and pedestrians around the work site, and
4. Enter manhole if necessary.

This section discusses items that should be considered before working in streets and entering manholes. REMEMBER that the procedures presented cannot cover all situations. YOU must consider your particular problems and APPLY the precautions discussed to your situation. Try to analyze your problems and develop procedures so you can DO YOUR JOB SAFELY.

4.11 Traffic Safety

Any time traffic may be disrupted, appropriate authorities must be notified. Many states and local municipalities require permits issued by a traffic engineer or police department BEFORE traffic can be diverted and streets or highways dug up. Determine local regulations regarding who must be notified and whose authorization or approval is needed. In areas with heavy traffic and congestion, notify police and request their assistance. Schedule work to avoid rush hour traffic.

Upon arrival at job site, look for a safe place to park vehicles. If they must be parked in the street to do the job, route traffic around the job site first.

Traffic must be warned of your presence in the street. "MEN WORKING" and "CAUTION, CONSTRUCTION WORK" signs are effective. Signs with flags or flashers and vehicles with rotating flashing lights are used to warn other motorists (Figures 4.1 and 4.2). Use flagmen to alert drivers and to direct traffic around the work site (Figure 4.3). Warning signs and flagmen must be located far enough in advance of the work area to allow motorists time to realize they must slow down, be alert for activity, and safely change lanes or follow a detour. Exact distances and nature of advance warning depend on traffic speed, congestion, roadway conditions and local regulations.

Once motorists have been warned, they must be safely routed around the job site. Traffic routing includes the use of flagmen and directional signs. Barricades and traffic cones properly placed can effectively channel traffic from one lane to another around the job site. Retain a traffic officer to direct traffic if streets are narrow and/or if there is considerable traffic or congestion.

If practical, park vehicles between on-coming traffic and the job site to serve as a warning barricade and to discourage reckless drivers from ploughing into workers.

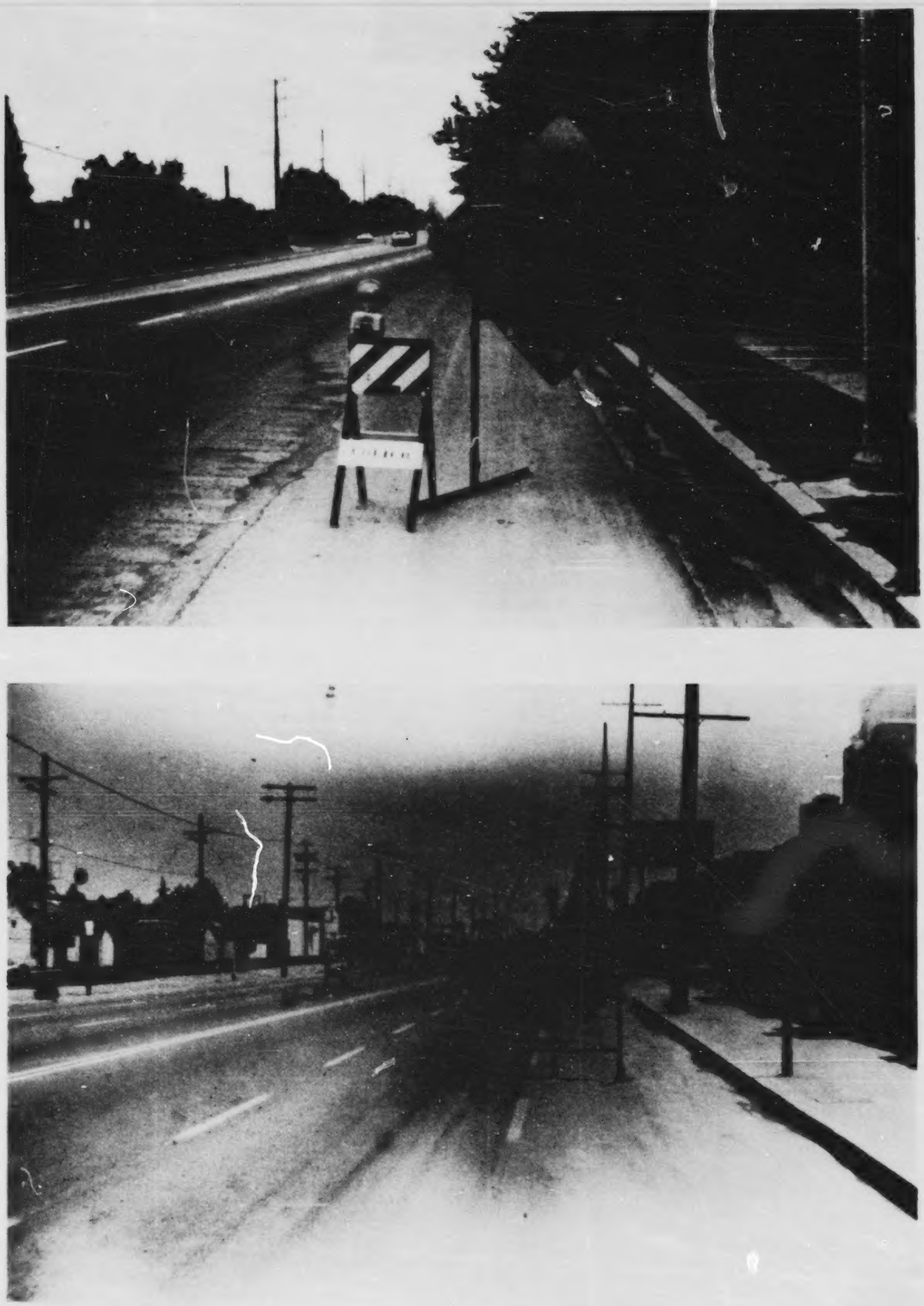


Fig. 4.1. Signs and barricades warning traffic
(Courtesy of the Bureau of Contract Administration, City of Los Angeles)

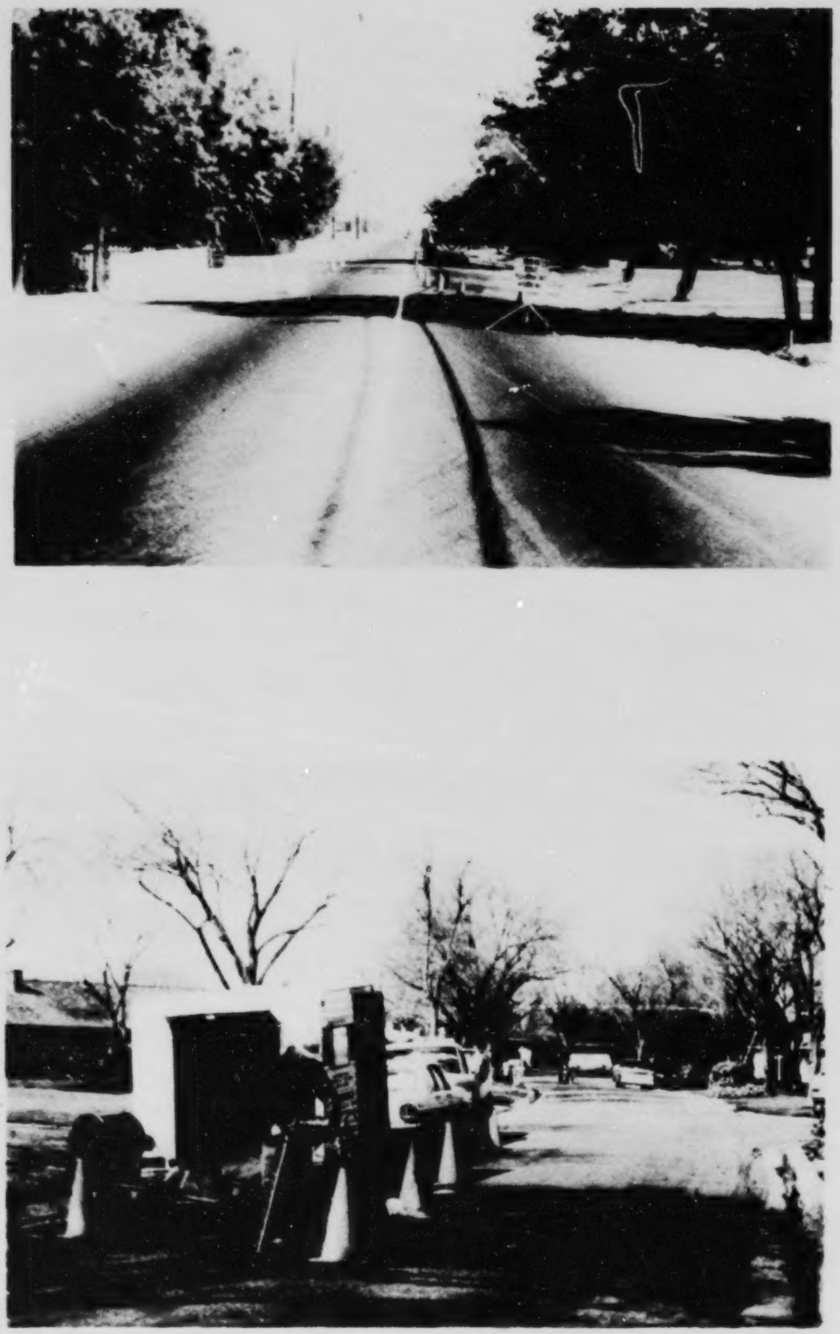


Fig. 4.2. Hi flags and cones routing traffic
(Courtesy of Water Quality Division, Sacramento County)

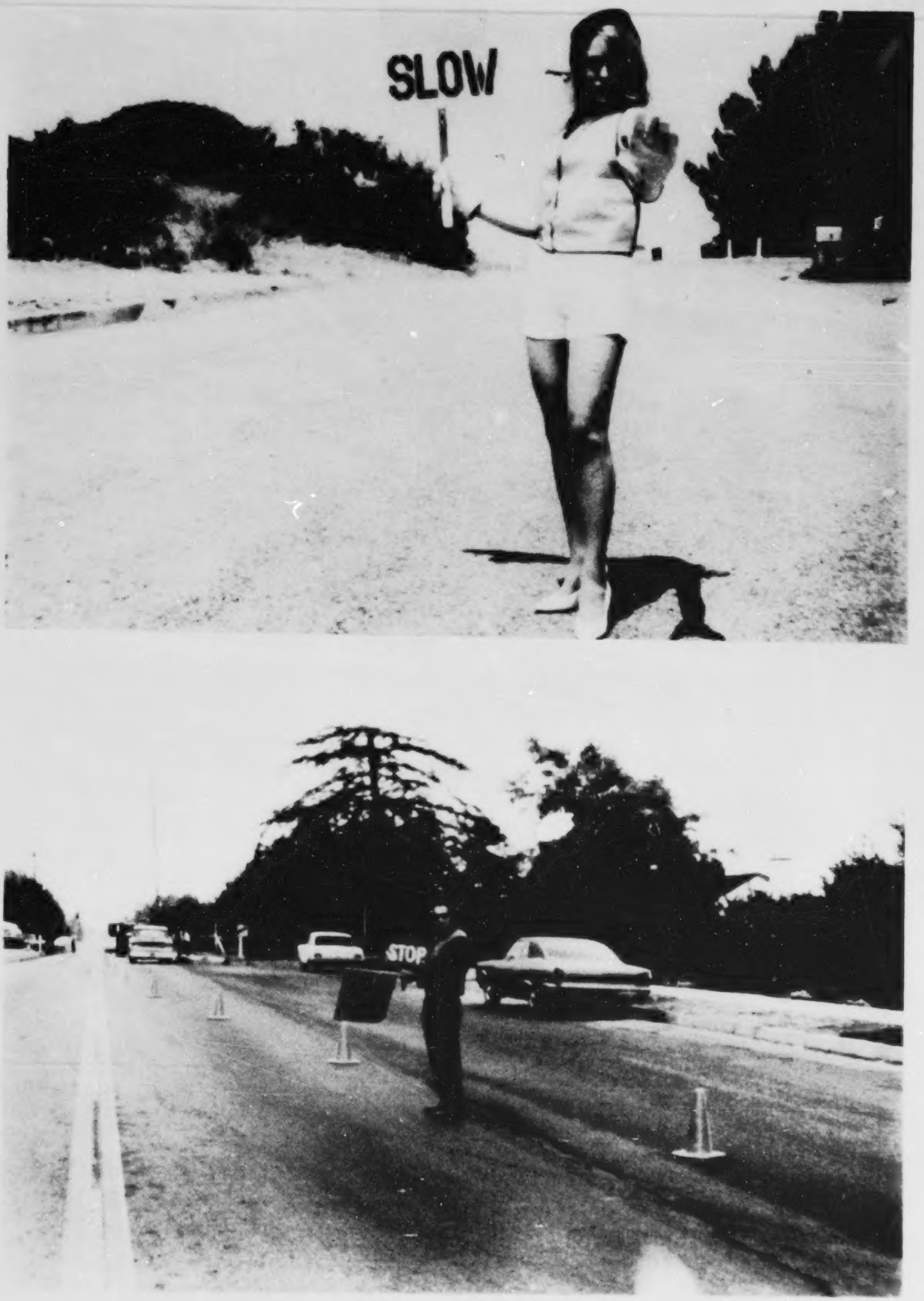


Fig. 4.3. Alerting and directing traffic
(Courtesy of the Bureau of Contract Administration, City of Los Angeles)

The next six pages show how to position hi flags, signs and cones for flagman control and work under five typical conditions:

1. Work area in center of road.
2. Work beyond intersection.
3. Closing left lane.
4. Closing half-roadway.
5. Closing right lane.

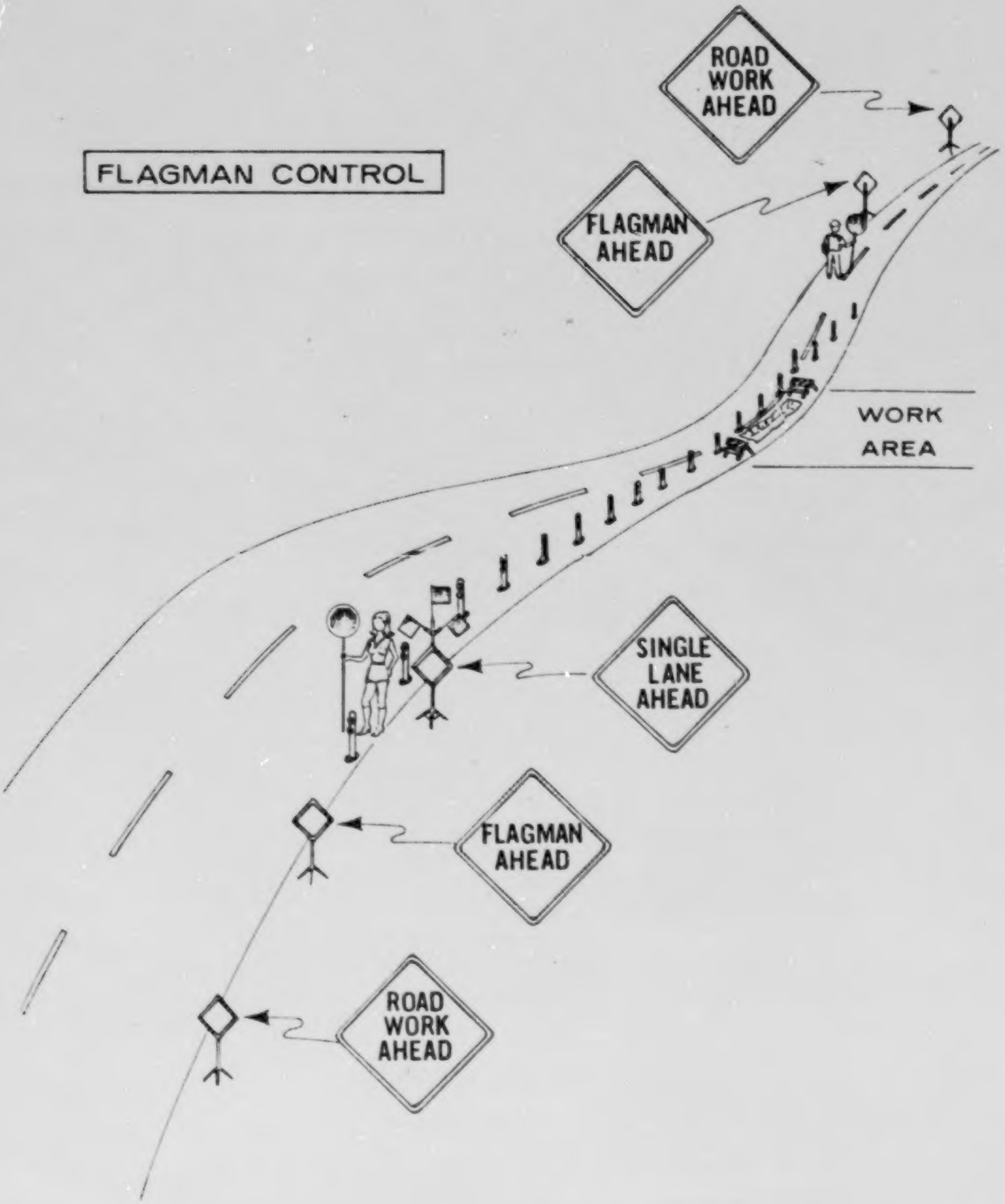
REMEMBER, YOU ARE SPEAKING A SIGN LANGUAGE-MAKE YOUR SIGNS SPEAK LOUD AND CLEAR!

Additional Reading

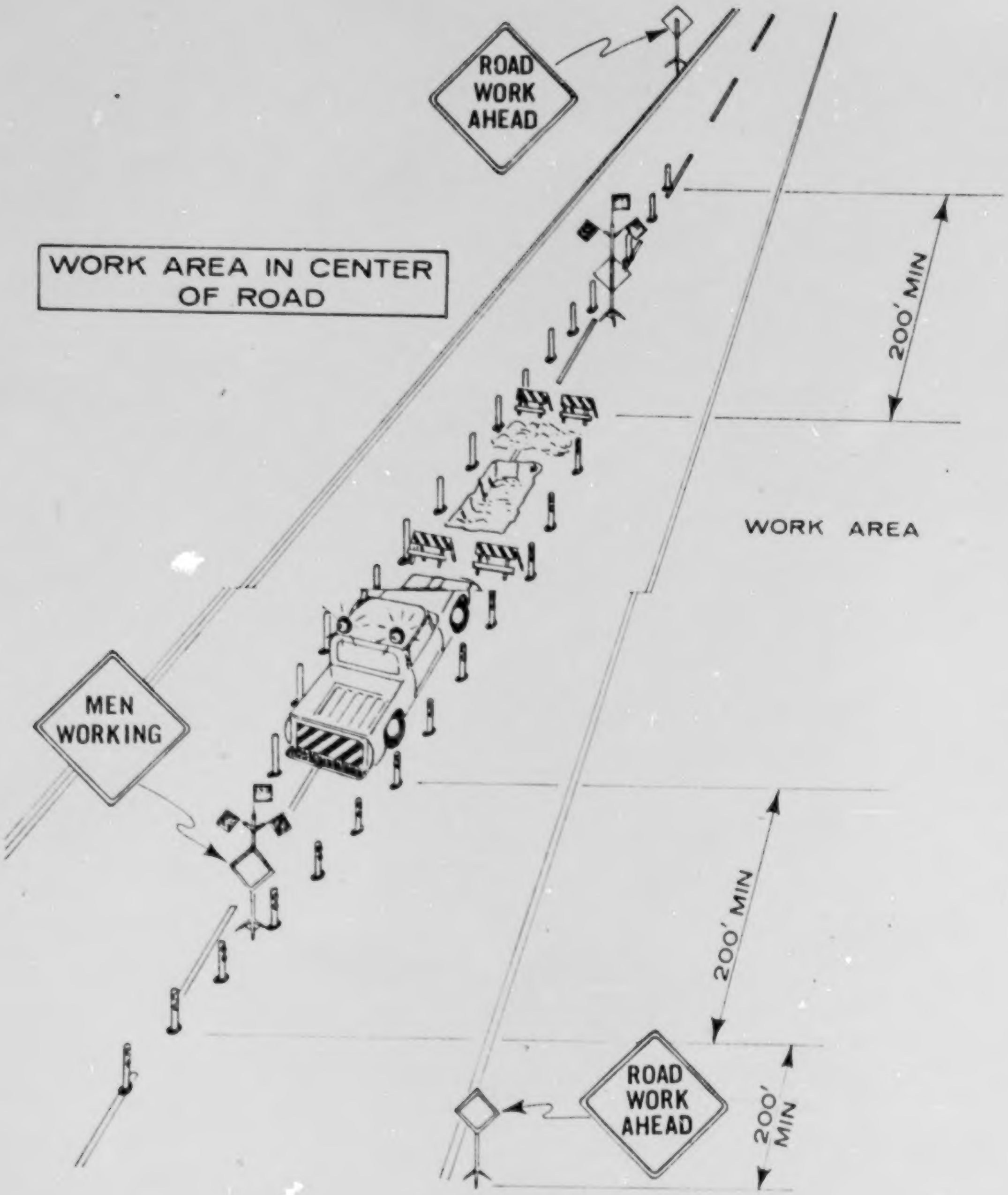
1. "Manual on Uniform Traffic Control Devices for Streets and Highways," U.S. Department of Transportation, Federal Highway Administration, 1971. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $3.50. Stock Number 5001-0021.

2. "Traffic Controls at Construction and Maintenance Worksites, Volume III, Field Manual," American Public Works Association, 1313 East 60th Street, Chicago, Illinois 60637.

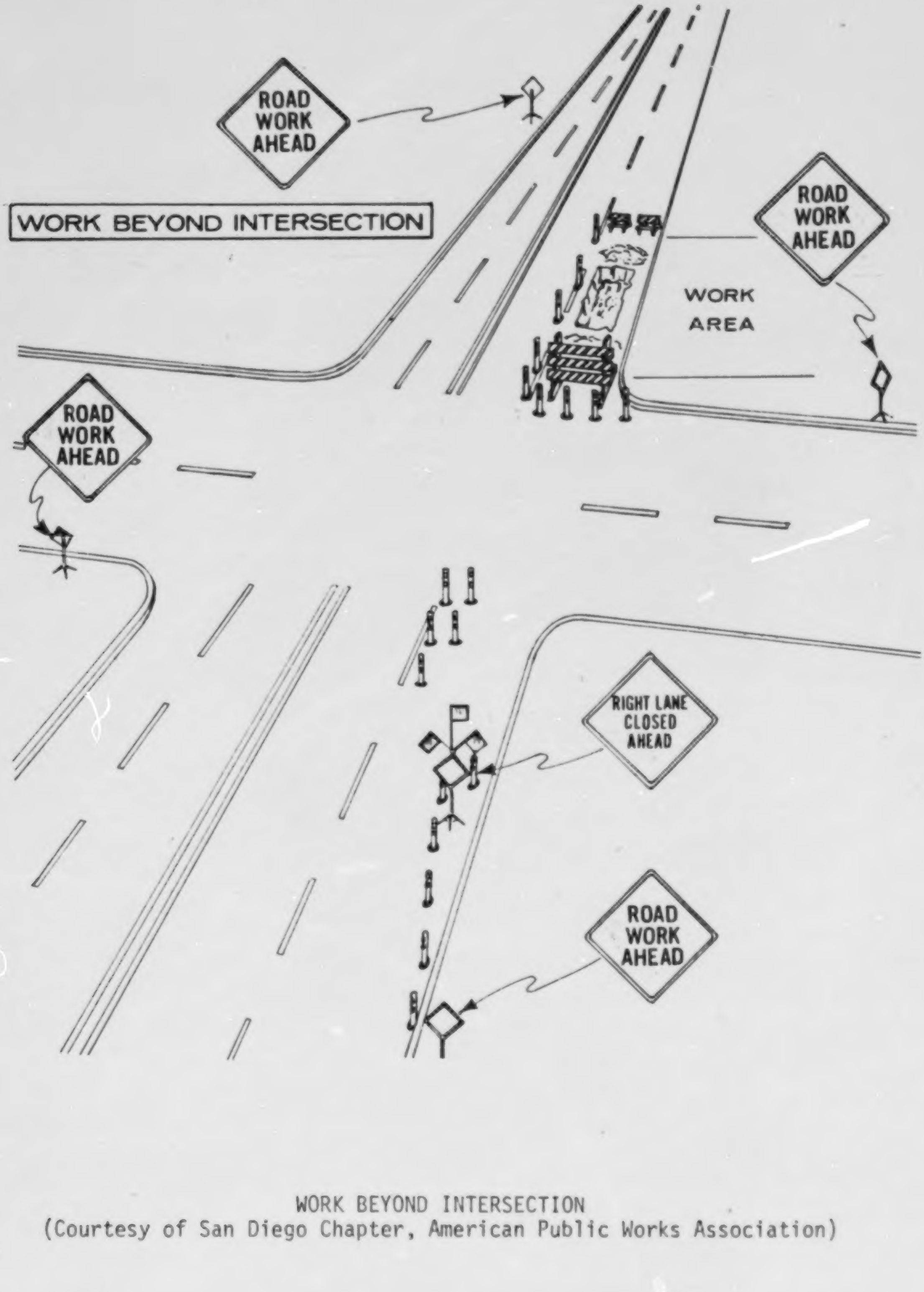
3. "Work Area Traffic Control," San Diego Chapter, American Public Works Association.


FLAGMAN CONTROL
ROAD WORK AHEAD
FLAGMAN AHEAD
WORK AREA
SINGLE LANE AHEAD
FLAGMAN AHEAD
ROAD WORK AHEAD

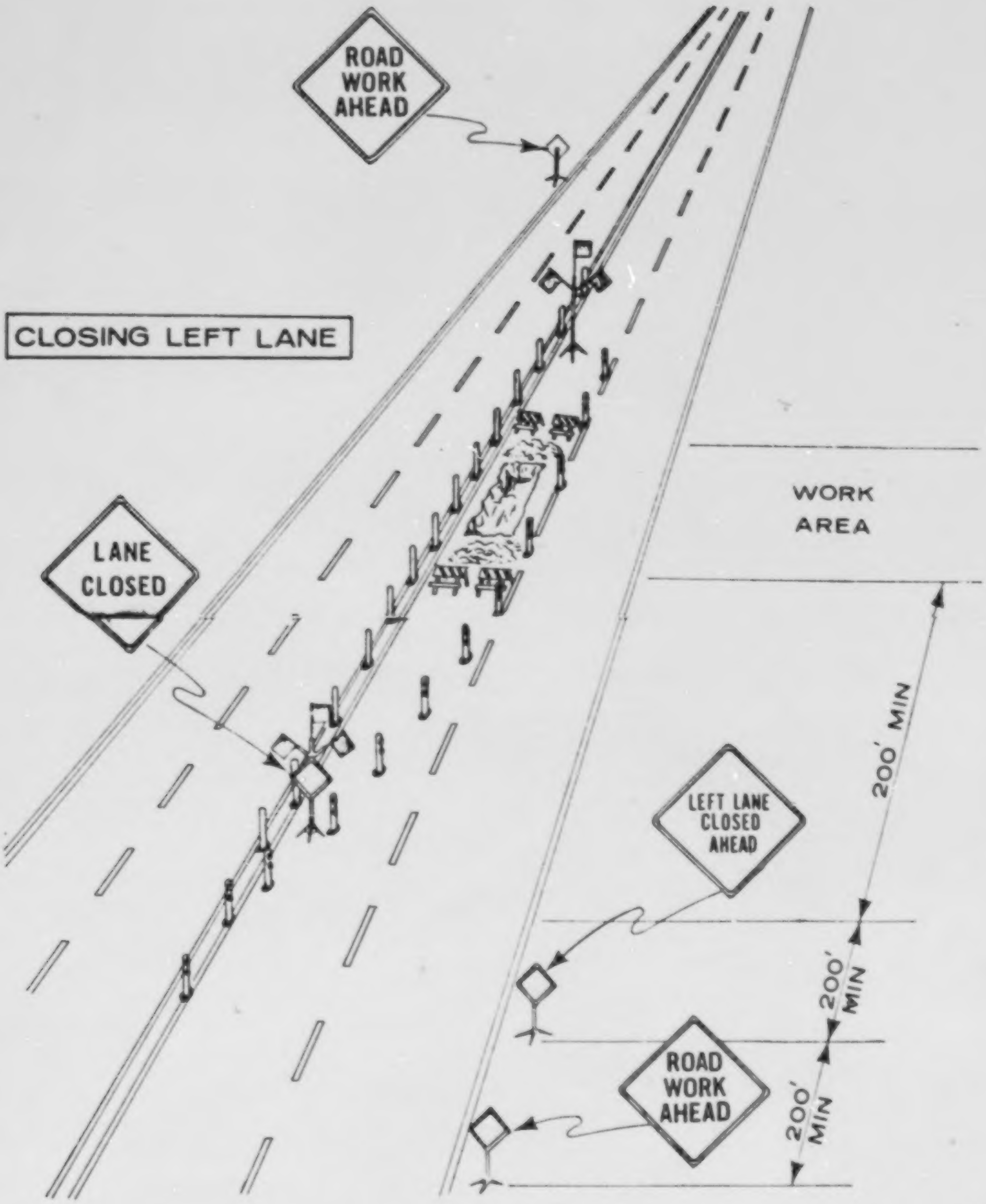
FLAGMAN CONTROL
(Courtesy San Diego Chapter, American Public Works Association)


ROAD WORK AHEAD
WORK AREA IN CENTER OF ROAD
200' MIN
WORK AREA
MEN WORKING
200' MIN
ROAD WORK AHEAD
200' MIN

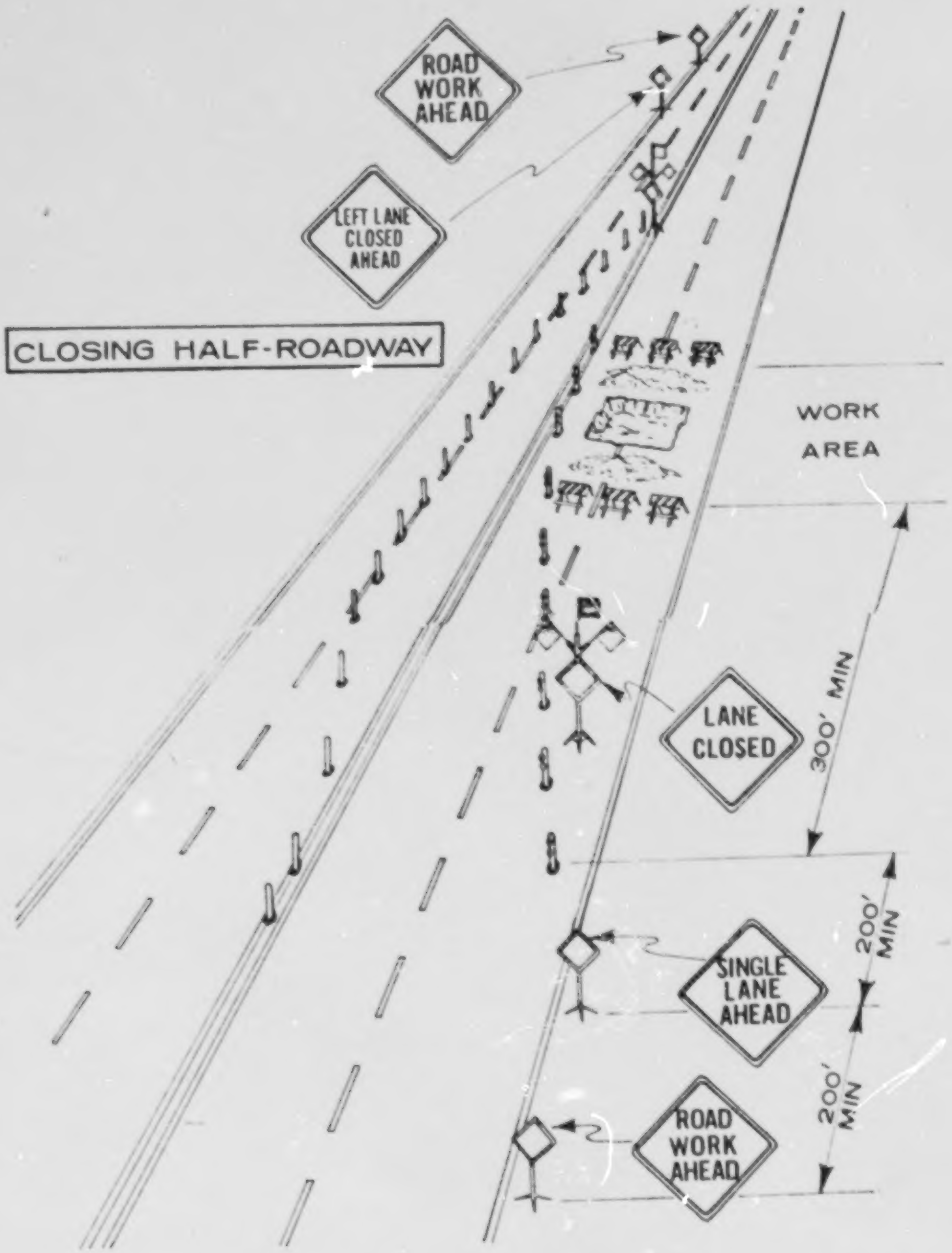
WORK AREA IN CENTER OF ROAD
(Courtesy of San Diego Chapter, American Public Works Association)


ROAD WORK AHEAD
WORK BEYOND INTERSECTION
ROAD WORK AHEAD
WORK AREA
ROAD WORK AHEAD
RIGHT LANE CLOSED AHEAD
ROAD WORK AHEAD

WORK BEYOND INTERSECTION
(Courtesy of San Diego Chapter, American Public Works Association)

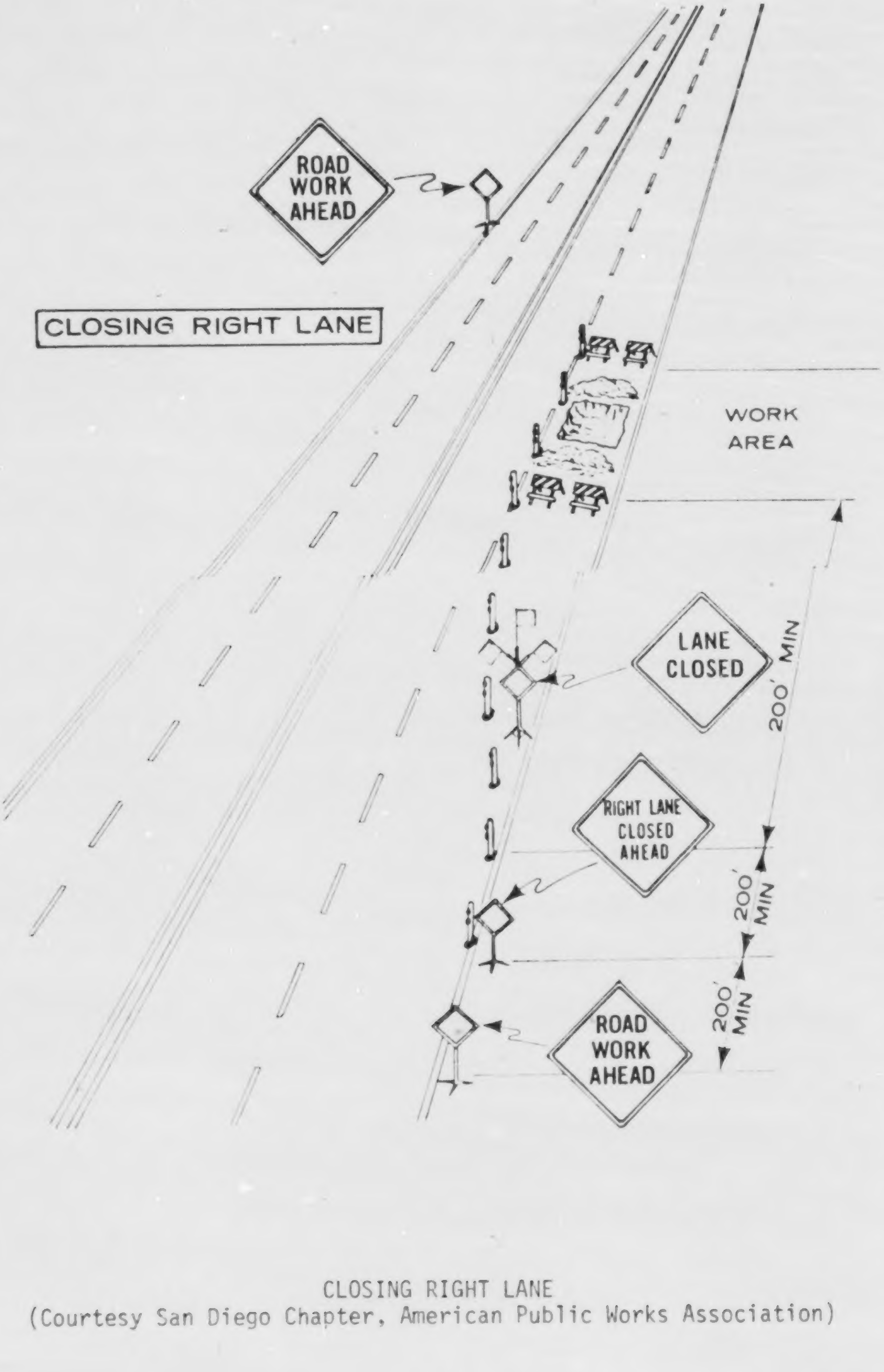

ROAD WORK AHEAD
CLOSING LEFT LANE
LANE CLOSED
WORK AREA
200' MIN
LEFT LANE CLOSED AHEAD
200' MIN
ROAD WORK AHEAD
200' MIN

CLOSING LEFT LANE
(Courtesy of San Diego Chapter, American Public Works Association)



ROAD WORK AHEAD
LEFT LANE CLOSED AHEAD
CLOSING HALF-ROADWAY
WORK AREA
LANE CLOSED
300' MIN
SINGLE LANE AHEAD
200' MIN
ROAD WORK AHEAD
200' MIN

CLOSING HALF-ROADWAY
(Courtesy San Diego Chapter, American Public Works Association)


ROAD WORK AHEAD
CLOSING RIGHT LANE
WORK AREA
LANE CLOSED
200' MIN
RIGHT LANE CLOSED AHEAD
200' MIN
ROAD WORK AHEAD
200' MIN

CLOSING RIGHT LANE
(Courtesy San Diego Chapter, American Public Works Association)

QUESTIONS

4.1A Who should be contacted before setting up a work site in a street?

4.1B What must be done SAFELY before inspecting, testing, cleaning or repairing sewers or manholes in streets or highways?

4.1C How can traffic be warned and routed around workers and equipment working on a sewer in a street?

4.1D Draw a sketch indicating how to warn and route traffic around a manhole in the right lane beyond an intersection.

4.12 Manhole Safety

Throughout this manual special safety precautions regarding specific jobs and procedures will be outlined. Everyone must recognize and understand the hazards encountered when entering a collection system manhole. Although the following discussion is brief, the collection system workers and their supervisors must become fully familiar with procedures discussed and apply them every time someone enters a manhole.

4.13 Classification and Description of Manhole Hazards

There are six major categories of hazards a person may encounter when entering a manhole. These hazards are discussed in order of known frequency of accidents and deaths to workers - atmospheric, physical injury (slips, falls, falling objects, sharp objects, bumps and structural failures), infection and disease, insects and biting critters, toxic exposure, and drowning.

4.131 Atmospheric Hazards

Atmospheric hazards consist of three major types - explosive or flammable, toxic atmospheres, and depletion or elimination of breathable oxygen. Do not allow unhealthy odors to distract your attention from the three major types of hazards that could kill you.

1. Explosive or flammable atmospheres can develop at any time in the collection system. Flammable gases or vapors may enter a sewer or manhole from a variety of legal, illegal or accidental sources. These conditions can be measured by the use of meters that indicate the explosive or flammable limits of the atmospheres.

   a. Methane gas is one of the products of waste decomposition. This gas can be produced almost anywhere in a collection system. Methane is also the major flammable gas in the natural gas piped under streets by utility companies. Leaks in these pipes will saturate a soil around a sewer pipe, and seepage will result in the gas entering the collection system and endangering workers in a manhole.

   b. While methane and natural gases are lighter than air, a small portion of the gas will diffuse or escape from a manhole if there is natural ventilation. Propane, gasoline, solvents and other explosive fuel gases may be as much as two-and-one-half times heavier than air and will tend to accumulate (if there is not ventilation) in the pockets of the lower portions of a collection system to form explosive mixtures or to displace air.

2. Toxic atmospheres (poisonous air) in wastewater collection systems or storm collection systems are most likely to be from the presence of hydrogen sulfide (H_2S), a gas produced by the decomposition of certain materials containing sulfur. Hydrogen sulfide gas quickly mixes with air and goes wherever the air goes. If there is no ventilation or air movement, H_2S accumulates in the lower sections of a collection system. Hydrogen sulfide can be detected

by the smell of rotten eggs or by the use of special test kits or instruments that measure the concentration of H_2S. Other toxic gases that may be encountered include chlorinated solvents and industrial toxins (poisons), depending on wastes discharged to the collection system.

3. The amount of breathable oxygen present in a manhole can be decreased or eliminated by having the air mixed or replaced by the entry of another gas. Meters are available that measure the concentration of oxygen in the air.

Do not work in confined spaces where the atmosphere contains less than 19.5% oxygen. Always ventilate the manhole before entry and continuously during occupancy. Continuously test all levels of manhole for oxygen deficiencies and explosive and toxic conditions.

Concentrations of oxygen in a confined space may exceed the level in the air we normally breathe (21.9%) when pure oxygen (O_2) is used to prevent septic conditions and the production of hydrogen sulfide in the wastewater collection system (See Chapter 5, Section 5.6, Hydrogen Sulfide Control). If the manhole is continuously ventilated and the oxygen level continuously measured, no problems should develop. A higher than normal level of oxygen won't hurt you, but will increase the fire or explosive hazard.

4.132 Physical Injury

Physical injury during manhole entry can occur from several causes. Workers in restricted spaces with uneven footing often have poor balance and decreased coordination. The manipulation of tools in restricted spaces often results in a worker being in an awkward position which can cause strained muscles or tendons, bruises or torn skin if the worker is not careful.

The use of heavy ladders for manhole entry and exit has been prohibited in many communities after these ladders have been dropped by accident while a worker is in a manhole. The practice of having metal rungs installed in manhole walls also has been discontinued by some agencies because the rungs or the concrete holding them was being eaten away and destroyed by the highly corrosive atmospheres of the collection system. Portable, lightweight, aluminum alloy ladders have proven satisfactory.

Dropping tools to workers in a manhole and tossing the tools back out has caused many physical injuries. In order for workers to see to catch a tool being dropped, they must look upward and into the brighter light, causing temporary loss of visual capacity. In addition to this, dust and debris from the street or manhole ring can fall into your eyes, again causing vision problems as well as possible eye infection if you attempt to wipe your eyes with a hand or glove that has been exposed to the wastewater environment. Tools should be lowered into and pulled out of manholes in a bucket or sling. Many collection system and treatment plant agencies use a truck winch to lower a worker and tools into a manhole. The man lift (Fig. 4.5, page 4-24) has a step, safety strap and snap, and a frame to avoid scrapes.

The use of spectacles or safety goggles in a manhole may be difficult because of their capacity to fog. These glasses also can become smeared by moisture in a manhole environment, thus resulting in decreased vision capacity by the wearer. Proper ventilation will reduce fogging problems. If a chipping gun or other tool is being used to chip concrete or pipe, safety glasses or goggles must be worn. A helmet and clear face shield worn by motorcyclists may be better than safety goggles.

When working in a manhole, beware of sharp objects that can cut or penetrate your skin and cause a serious infection. Typical sharp objects include razor blades, pins, hypodermic needles and broken pieces of glass and metal.

QUESTIONS

4.1E List the hazards you may encounter when entering a manhole.

4.1F What kinds of atmospheric hazards are encountered in manholes?

4.1G What are some of the causes of physical injuries in manholes?

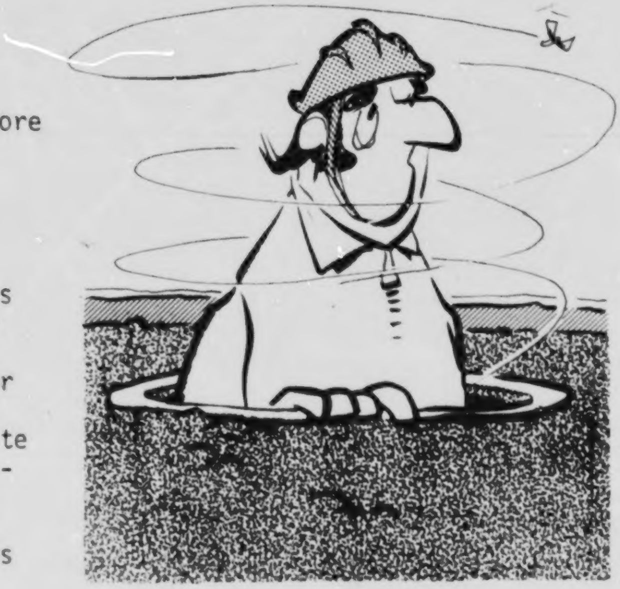
4.133 Infections and Diseases

Infections are always potentially present when you enter a manhole. Every disease, parasite, infection, virus and illness of a community can end up in the wastewater collection system. Persons required to enter manholes are thus automatically exposed to these infections and diseases. Leptospirosis can be transmitted to workers through the urine and feces of rats living in sewers. This disease causes fever, headaches, nausea, muscular pains, vomiting, and thirst. Contact your safety officer or doctor regarding inoculations for typhoid, para-typhoid, polio and tetanus. Personal cleanliness is your best means of protection. If possible, have a commercial laundry service clean your uniform rather than wash your clothes at home with your family laundry.

4.134 Insects, Bugs and Rodents

Insects, while less severe in danger to workers than infections and diseases, can be a source of danger. The black widow and the violin spider are examples of threats to your health. Many bites are associated with infections, for examples, rat bites can cause rabies and mosquito bites can cause malaria. Following is a list of insects and bugs which have been found in manholes.

Stinging insects such as wasps, mud daubers and bees
Ticks
Fleas
Lice
Mosquitos
Houseflies
Bloflies



Always inspect a manhole for insects, bugs and rodents before entering.

4.135 Toxicants

Exposure to toxic acids, bases and other hazardous liquid or solid chemicals that can be discharged into the wastewater collection system by either accidental spills or deliberate action by industry or the public is always a potential health hazard. Proper boots and gloves are effective means of protection against these toxicants.

4.136 Drowning

With the trend towards larger regional wastewater treatment plants, intercepting sewers are being constructed that convey large flows. These large diameter sewers and flows increase the chances of a worker drowning from an accidental slip or fall into the flowing wastewater. Watch your step at all times, especially when working near or in large flows to avoid drowning. Wear lift jackets and use lifelines if necessary.

4.137 Summary

Manhole entry always must be considered a hazardous task due to the potential exposure to chemicals, toxic and explosive gases, insects and infectious conditions. Work in manholes can be done safely when the proper procedures are followed.

QUESTIONS

4.1H How can you protect yourself from diseases when working in a manhole?

4.1I How can you protect yourself from insects when working in a manhole?

4.14 Safety Equipment and Procedures for Manhole Entry

The pieces of equipment described below are recommended for use when workers are required to enter a collection system manhole.

4.140 Self-Contained Breathing Apparatus

This apparatus consists of a face mask respirator and hose to the air supply. Air may be supplied either from a tank carried on the worker's back or from larger cylinders placed at a convenient location and not carried around by the worker. Use when ventilation is unable to provide a suitable atmosphere in a manhole or confined space.

4.141 Safety Harness with Lifeline

The harness should be a parachute type which prevents a limp body from falling out of it. The lifeline connection should attach at the shoulders so as to suspend a body in the upright position. Tilting or doubling over of a body can prevent its rapid removal through the 24-inch manhole opening, or cause injury to a person while being removed in the doubled over or tilted position.

The harness and lifeline may be used to lower a worker into a confined space. Whenever a worker is underground (in a manhole), someone must be topside holding the lifeline and observing the actions of the worker in the harness. Do not tie the above ground end of the lifeline to any object that could be hit by a careless driver that could result in injury to the worker in the harness.

4.142 Portable Oxygen/Explosivity Alarm Unit

This device should be the type that continuously withdraws a sample of the atmosphere from a manhole and tests it for the presence of explosive or flammable gases and the percentage of oxygen or that is equipped with a sensor or probe that is lowered into the manhole. The device should have an audible and visible alarm that will warn when flammable gases (such as methane, CH_4) exceed 20 percent of the lower explosive limit (LEL) or when the oxygen percentage drops below 19.5 percent. A device also must be available to test for hydrogen sulfide gas and any other toxic gases that might be present. Battery operated units also should have an alarm to indicate low battery power before such power becomes inadequate to permit equipment to properly function. These gas testing devices must be maintained and in proper operating condition at all times. Be sure these devices receive regular preventive maintenance.

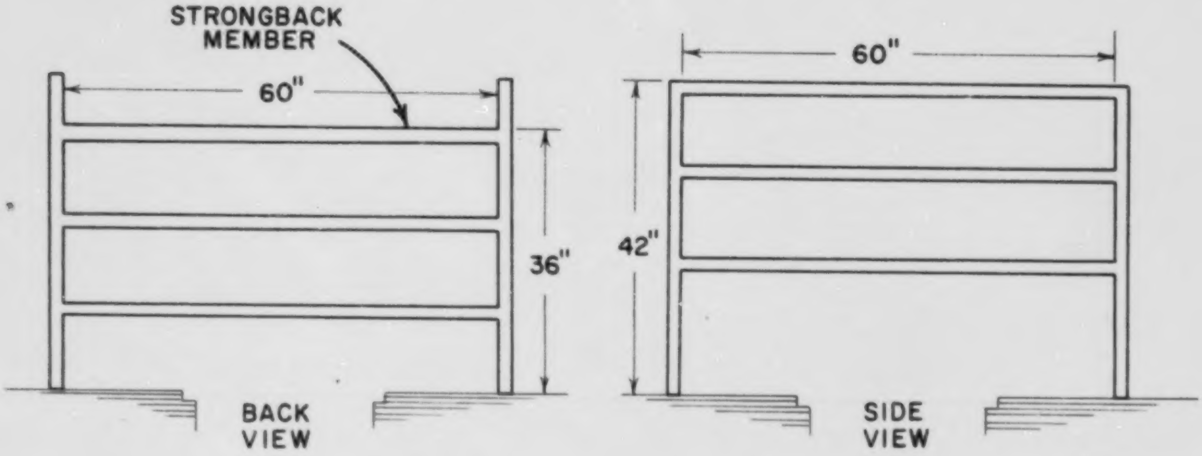
4.143 Ventilation Blower with Hose

Blower must be on 10 to 15 minutes before entry to a manhole with the hose outlet all the way down to the bottom of the manhole. A fan type blower driven by an electric motor or truck power should have between 750 and 850 CFM capacity for a standard manhole with a 4-foot diameter at the bottom. The standard unit will have a 15-foot long hose, eight inches in diameter to conduct the blower air to the bottom of the manhole. Hose couplings and extensions must be available because some manholes are over 30 feet deep. Gasoline engine powered blowers are less desirable due to the high noise factor, and the possibility of producing undesirable fumes and gasoline leaks. Some agencies use blowers powered by bottled gas. One problem encountered in using blowers is that blowing air into a manhole can create pockets of gas. Ventilation can be improved by removing the nearest upstream or downstream manhole cover.

Another approach is to draw air from the bottom of the manhole. This method is acceptable if the new air that flows into the bottom of the manhole is satisfactory for breathing and does not contain flammable or toxic gases. If there is an air space in the downstream pipe, air may be exhausted or drawn from the downstream manhole. Thus, the person in the manhole is breathing fresh air from the manhole entrance.

4.144 Manhole Enclosure (See Figure 4.4)

An enclosure that may be set up around the open manhole to prevent unauthorized persons from endangering the worker in the manhole or

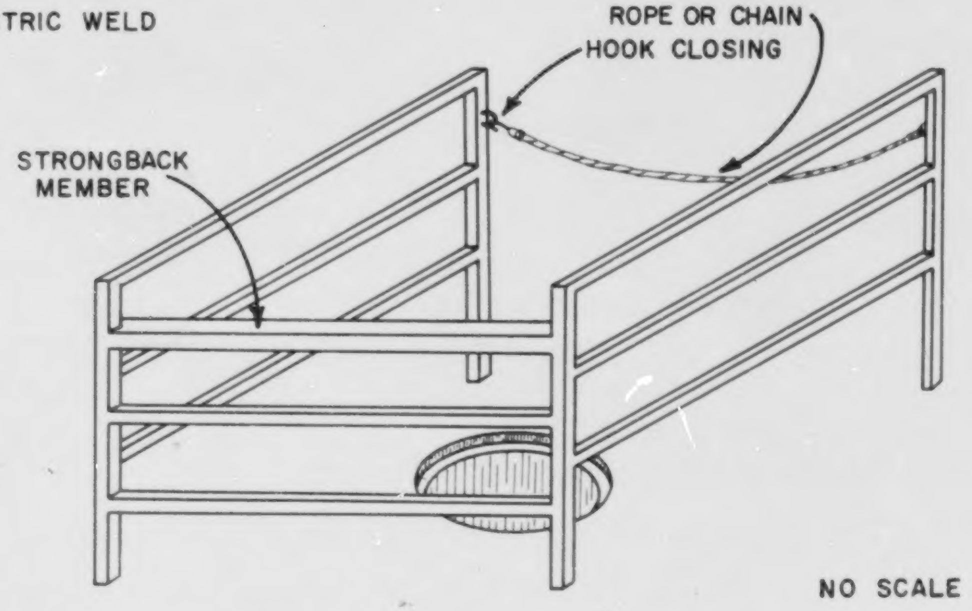

STRONGBACK MEMBER
60"
36"
BACK VIEW
60"
42"
SIDE VIEW

MATERIALS SCHEDULE

STRONGERBACK 1 - 1 1/2" BLACK PIPE
REMAINDER - 3/4" BLACK PIPE
(OR OTHER WITH EQUIVALENT STRENGTH)

CONSTRUCTION METHOD

ELECTRIC WELD


ROPE OR CHAIN
HOOK CLOSING
STRONGBACK MEMBER
NO SCALE

FINISH

SAFETY ORANGE OR YELLOW

NOTE: Strongback member and both sides should be coupled together so they can be stacked for transportation and quickly assembled if needed.

Fig. 4.4. Typical portable manhole safety enclosure

from falling in themselves. This structure should be of adequate strength to support the weight of a worker when required. Do not use an enclosure if it interferes with the work of a crew or their safety.

Some agencies use a "toe board" too. This is a metal ring which fits into the manhole frame and extends a minimum of four inches above the ground. The purposes of this device are to prevent objects from rolling into the manhole and to provide protection against people walking into an open manhole.

4.145 Aluminum Ladders and Man Lifts

Lightweight aluminum alloy extension ladders are often used in shallow manholes. They are easy to handle and to climb.

Man lifts (Figure 4.5) are used by some agencies to avoid the use of ladders or steps in manholes, wet wells and other below ground enclosures, especially deep manholes. The worker has guard rails around the body for protection against scrapes and a canopy over the head for protection against falling objects. After the worker has been lowered to the work area, the man lift is raised and a tool bucket is lowered to the work area with the necessary tools, equipment and materials.

Some agencies require workers to stay in the man lift or cage when they work in a manhole. The type of job, working conditions and design of the man lift determine whether or not a person should remain in the man lift.

4.146 Ropes and Buckets

Tools for use by workers in a manhole must be lowered to them and recovered from them by the use of a bucket. Lower the bucket with a hook rope with a safety clasp that will swivel. Dropping tools for them to catch and allowing them to toss tools out has resulted in many injuries and should result in immediate warning or dismissal of the guilty workers.

4.147 Hard Hats

No person should be allowed to enter a manhole without adequate head protection. The full strength hard hat is recommended. The brim should be adequate to protect the nose or a clear face shield should be used. Chin straps are almost a necessity in confined quarters.

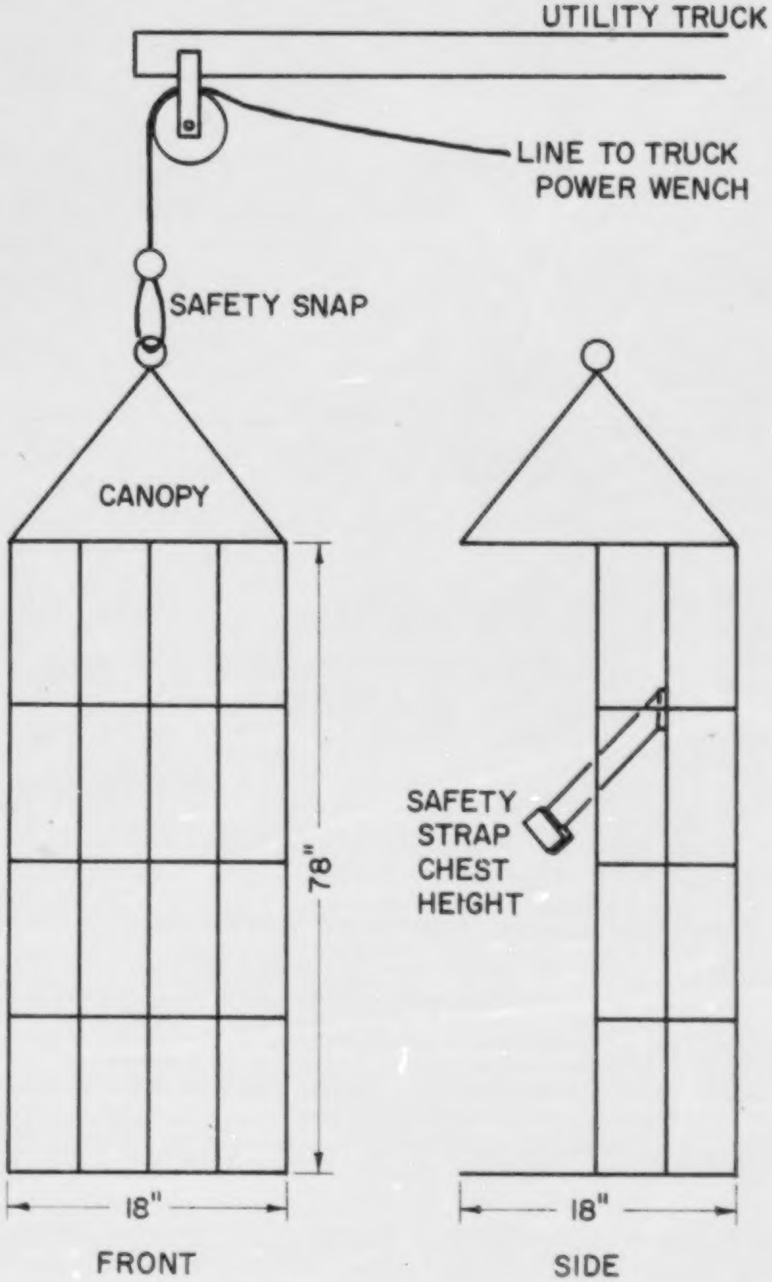

UTILITY TRUCK
LINE TO TRUCK POWER WENCH
SAFETY SNAP
CANOPY
78"
SAFETY STRAP CHEST HEIGHT
18"
FRONT
18"
SIDE

Fig. 4.5. Man lift

4.148 Protective Clothing

As much of a person's skin as possible should be covered with clothing that will prevent scrapes and abrasions. No one should ever be permitted in a manhole that has once been in service unless fully clothed with shoes, gloves and long sleeves. Selection of clothing depends on actual working conditions such as the temperature and the job to be done. Gloves are usually recommended. Some people prefer not to wear gloves because they get wet and wastewater can run down your arms when working. Whether gloves are worn or not, always thoroughly clean your hands before smoking, eating, or leaving the job site. Cleaning can be accomplished using waterless soap and paper towels. Clothing should be provided collection system workers, including shoes with steel toes.

4.149 Other Equipment and Procedures

1. Cones, Barricades and High Level Flags: When working in areas with vehicle traffic present, cones, barricades and high level flags should be used always. A utility truck is an effective barricade. This equipment and its proper application is discussed in Section 4.11, Traffic Safety.
2. First-Aid Kit: A suitably equipped first-aid kit should be on hand and immediately available for use where workers will be in manholes. Artificial respiration tools and devices should be essential to this kit. Antiseptic solutions for application on wounds or scrapes are another important requirement of this first-aid kit. Eye washing solutions as well as the irrigation or rinsing eye cups should be included. If crews must work in areas where they could come in contact with poison ivy or poison oak, solutions to relieve itching are essential. At least one or more crew members should be trained in the use of first-aid equipment and procedures.
3. Fresh Water, Soap and Clean Cloths: After leaving a manhole, a strong soap and clean fresh water should be available to a worker for washing hands and face. Waterless antiseptic hand cleaners also are effective and approved for washing purposes. Paper towels may be used for the wiping process. This is very important if the worker smokes or is going on a lunch or coffee break. Clean clothes should be put on after working in a manhole.

QUESTIONS

4.1J List the safety equipment recommended for use when workers are required to enter a manhole.

4.1K What kind of gas detection device is necessary when entering a manhole?

4.1L What toxic gas is commonly found in wastewater collection systems?

4.15 Precautions for Manhole Entry

4.151 Immunizations

Workers in a wastewater collection system should have current immunizations against illnesses and diseases which might be encountered in the collection system. Requiring typhoid and tetanus shots with booster shots every five years is the policy for many agencies. Contact your safety officer or personal physician for recommendations

4.152 Disinfectants

In cases where a manhole that must be entered is located reasonably close to the discharge of a hospital, venereal treatment center, clinical laboratory, surgical facility, or a veterinarian's office and hospital, a disinfectant may be required in the manhole and the upstream line one or two hours ahead of scheduled entry. While this action may result in other problems and strong odors in the manhole, this may be recommended procedure rather than risk exposure to the diseases which are possible in such manholes. Because disinfectants are poisons, do not enter a manhole when the odor of a disinfectant is present.

Most state and local health departments have laws and regulations that prevent the discharge of infectious wastes into wastewater collection systems until after they have been disinfected (usually in an autoclave that disinfects by using steam). Contact the medical officer in charge of any medical facility immediately upstream from manholes and sewers in which you must work. This person can explain the disinfection procedures used by the medical facility, indicate if the threat to your health is greater than usual, and recommend any special precautions or disinfectants that may be necessary.

4.153 Health Conditions of Workers

Any worker entering a manhole should conform to the following rules at the time of entry:

1. Be in good health. If you are recovering from a recent illness or surgery, do not enter a manhole until fully recovered.
2. Not have a hangover nor be under the influence of alcoholic beverages or drugs.
3. Be in sound physical condition.
4. Have no open sores, skin irritations (including such things as poison oak), fungus infection (athlete's foot as example) or serious sunburn.
5. Workers who do not require corrective glasses for manhole tasks are preferred for such work.

Other workers on a manhole entry crew also should be in good health with necessary physical capacities to accomplish required work.

4.154 Insecticide

Where insects have been a problem, and where rats or other vermin may occupy a collection system or where epidemics of insect born diseases may be present, spraying a manhole with an insecticide is suggested. The solution should be water soluble and leave a toxic residue to be effective against the next hatch of any insects present and breeding in the collection system. Spraying should be conducted at time of entry if insects or other problems are observed. Ventilate manhole so insecticide will not be inhaled by workers.

4.155 Wash Down

If a manhole is especially filthy or odorous from hydrogen sulfide or an insecticide, wash down the manhole with high velocity, clear water before sending a man down into the manhole. This wash is

best accomplished within an hour or so before manhole entry.

4.156 Required Tools, Materials and Equipment

Prior to sending a worker into a manhole, a careful inventory and examination of condition of all required tools, materials and equipment needed for the work should be made. Exposure to injury is greatest while a worker is descending into or climbing out of a manhole. Therefore, job organization and equipment requirements should be arranged to permit all work to be accomplished with a single entry and exit of the manhole.

4.157 Equipment Test

Before leaving your maintenance yard at the start of each day, safety equipment should be carefully inspected and tested. Where functional capacities are doubtful, replacement equipment should be used while the defective or suspected equipment is repaired or further tested.

4.158 Briefing

Just prior to entry, the foreman or crew leader should hold a short briefing on the project, the order of accomplishment and the safety rules that must be observed. All members of the crew should be fully informed of all aspects of the project and procedures that will be followed in event of any emergency.

QUESTIONS

4.1M What kinds of preparations should be made before workers enter a manhole?

4.1N What are some of the health conditions of workers that should be considered before entering a manhole?

4.1O The briefing before manhole entry should discuss what topics?

4.16 Operations of Manhole Entry

The minimum crew for a worker to enter a collection system manhole is three workers: the worker who will go into the hole, the lifeline attendant and an assistant on the surface. The arrangement of the safety and other equipment is generally accomplished by the entire crew, however a support crew may be necessary to direct traffic and provide other needed assistance.

1. The manhole safety enclosure is placed around the manhole if necessary.

2. The portable explosivity/oxygen alarm system is calibrated BEFORE removing the manhole cover. Test the manhole from top to bottom for oxygen deficiency, explosive and toxic (hydrogen sulfide) gases. Test for explosive mixtures before removing the manhole cover because removal of the cover may produce a spark and cause an explosion. Also it is helpful to know conditions in the manhole before any ventilation occurs.

   If an explosive atmosphere is discovered in a manhole:
   a. Immediately notify your supervisor that an explosive condition has been discovered and provide as many details as possible, including location. Request notification of police and fire departments.
   b. Do not remove the manhole cover.
   c. Turn off any running engines in the vicinity that could cause a spark.
   d. Route vehicles around manhole using cones, flags and barricades.
   e. Inspect upstream and downstream manholes for explosive conditions to determine the extent of the problem.

   f. Route traffic off the street to reduce potential for explosion.
   g. Notify industrial waste inspectors and wastewater treatment plant operators.
   h. Attempt to locate source of problem and correct situation.
   i. Cautiously ventilate system with a large blower to eliminate explosive hazard. Try ventilating from a safe upstream or downstream manhole in order to keep workers and equipment away from explosive conditions.
   j. Be sure there is NO SMOKING in the area.

3. Never use hands to remove or replace the manhole cover. Always use manhole lifts approved by the safety agency that regulates your activities.

4. Open manholes upstream and downstream from the work area to encourage natural ventilation of sewer. Cover open manholes with grating and place barricades around manholes to warn traffic and pedestrians.

5. The area immediately around the manhole opening, including the manhole ring and lid ledge, should be cleaned and all loose debris removed. Sweep the area before removing the manhole cover and clean the ring ledge after the cover has been removed.

6. The ventilation blower is started and the manhole atmosphere blown out prior to entry. The blower should be located in an area upwind of the manhole and at least ten feet from the manhole opening. If the blower has a gas driven engine, the exhaust must be downwind from the manhole. Place the air intake to the blower from two to five feet above the ground surface, depending on conditions (higher for dusty ground surfaces). Some agencies prefer to exhaust or pull air from the downstream manhole if possible.

7. Once the man going into the hole has donned the safety harness and had the lifeline attached, the other man on the crew or the foreman should check it for proper fit and attachment.

8. Continue to use the alarm system to test for the presence of an oxygen deficiency and explosive gases in the manhole atmosphere the entire time the worker is in the manhole.

4.17 While Worker Is Down in the Manhole

1. The end of the lifeline must be held continuously by a crew member (Fig. 4.6). This person shall perform no other function, but keep constant watch over the worker in the manhole. Tying the lifeline to prevent it from falling into the manhole is poor practice, especially if it is tied to an object that could be struck by a passing vehicle and cause injury to the worker in the manhole.

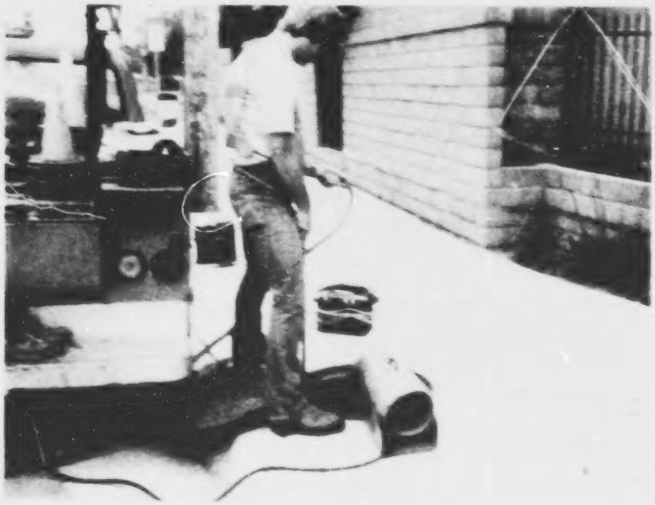


Fig. 4.6. Holding lifeline

How many safety hazards can you spot in Fig. 4.6?
No gloves, no hard hat, manhole cover balanced on curb, manhole cover between workers legs instead of out of the way, second worker topside missing, safety cones to warn pedestrians missing, and vehicle too close to manhole, thus not allowing adequate working room.

2. The safety enclosure will always contain one worker who holds the lifeline, observes the worker in the manhole, and calls for help if needed. Safety enclosures are not considered necessary by some agencies.

The worker holding the lifeline should be careful to secure any objects he has in his shirt or jacket pockets so that they will not fall into the manhole when he bends over it. Also he must be careful not to accidently kick any tools or objects over the edge of the manhole.

3. As long as the worker is in the manhole, the worker holding the lifeline should carefully watch the worker and not distract him. Always listen and respond to the needs and condition of the worker in the manhole.
    a. If there are any indications of trouble such as unusual behavior or warning signals from the gas/oxygen alarm system, immediately bring the worker up out of the manhole.
    b. Whenever a worker is in a manhole, continuously test the atmosphere for oxygen deficiency and for explosive and toxic (hydrogen sulfide) gases. Proper ventilation generally will prevent any problems with the manhole atmosphere from developing except during a dump up sewer. If the flammable gas level is within only 10 percent of the lower explosive limit (LEL), this is an indication that ventilation is ineffective.

4.18 Special Problems of Manhole Work

1. Manholes will have a capacity for strong odors and many of these odors can cause olfactory fatigue. This is a condition where a sharp odor or prolonged breathing of an odorous atmosphere will cause the sense of smell to be temporarily lost.

   If a smell of gas or some dangerous substance is noticed when first opening a manhole lid, the lack of such a smell at a later time must never be taken as an indication that the source or danger has been eliminated. Continuously ventilate and test the manhole atmosphere for oxygen deficiency and for explosive and toxic gases whenever someone is in a manhole. Don't depend on odors to provide warnings; but when you smell a potentially harmful odor (such as hydrogen sulfide), recheck the atmospheric testing system.

2. Where the atmosphere in a manhole has been displaced by a gas that has no breathable oxygen in it, life expectancy for anyone entering the manhole is approximately 180 seconds with awareness of a problem lasting less than 30 seconds.

Under these conditions, a power operated man lift (Fig. 4.5) is essential because the worker doesn't have the strength to climb out of the manhole.

WARNING

NEVER ALLOW ANYONE TO ENTER A MANHOLE UNTIL THE OXYGEN CONTENT OF THE MANHOLE HAS BEEN TESTED AS BETWEEN 19.5 AND 21 PERCENT OXYGEN.

3. A lowering of the oxygen content in the air you breathe can result in a serious injury. The early warning signs that the topside worker holding the lifeline should be looking for include:

   1. Labored breathing (shortness of breath),
   2. Chest heaving, and
   3. Change from usual responses.

   WARNING: ONLY AN EXPERT SHOULD GIVE A WORKER SUFFERING FROM A LACK OF OXYGEN PURE OXYGEN IN AN ATTEMPT TO REVIVE THE WORKER OR TO ASSIST THE WORKER. TOO MUCH OXYGEN IN A WORKER'S BLOOD CAN BE DEADLY ALSO.

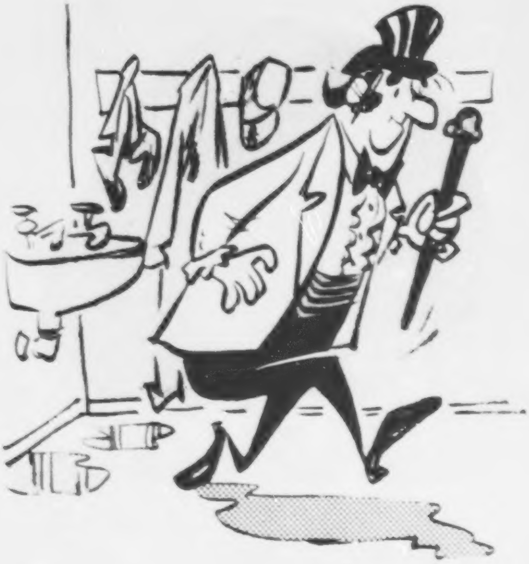
   Victims suffering from a lack of oxygen may require artificial respiration if the case is severe. If victim is still breathing without assistance, pure fresh air is safe and effective.

4. Truck mounted boom type hoists are sometimes used for lowering and lifting a worker out of a manhole while the worker is in a safety harness. An electric operated boom of this type must have an automatic power kill switch on the boom when maximum cable length has been recovered by the drum.

5. Safety equipment manufactured under such headings is required to pass rigid performance and quality tests. Such labels as Underwriters Laboratories, and Factory Mutual indicate this qualification. Always test equipment under conditions of use to learn how the equipment works and to be assured that it will work when needed.

4.19 After Leaving Manhole

A person who has been in a collection system manhole should have a hot shower and put on clean clothes before leaving work at the end of the day. Under no circumstances should the clothing worn in the manhole be worn home. Never expose your family to any contageous infection that might have come into contact with your clothing. No clothing worn in sewer maintenance or repair work should be worn home or washed with the family laundry.



QUESTIONS

4.1P What is the minimum size of a crew when someone enters a manhole?

4.1Q What should the worker at the manhole entrance be doing while another worker is in the manhole?

4.1R What is the minimum level of oxygen in air for safe breathing?

4.1S What should a worker do after leaving a manhole?

RESPONSIBILITY

The crew leader or foreman has the responsibility to be sure all work is conducted in a safe and prescribed manner. If not, in some states the person in charge can be held liable and subject to both a fine and imprisonment. The employer may pay the fine, but the responsible person must serve the time.

Additional Reading

1. Chapter 9, Safety for the Collection System Worker, in this manual.

2. Safety in Wastewater Works, Manual of Practice No. 1, Water Pollution Control Federation, 2626 Pennsylvania Avenue, N.W., Washington, D. C. 20037. Price: $0.75 to members, $1.50 to others. Indicate your member association when ordering.

END OF LESSON 1 OF 5 LESSONS
ON
TESTING AND INSPECTING COLLECTION SYSTEMS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 1 of 5 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. What are the reasons for inspecting and testing wastewater collection systems?
2. How would you warn and route traffic around a crew working in a manhole located in a street?
3. What are the three types of atmospheric hazards that may be encountered when entering a manhole?
4. Why must equipment used for manhole entry be in good repair and working properly?
5. Why must people working in a manhole be in good physical condition?
6. What is the responsibility of the crew leader or foreman when work is conducted in a manhole?

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 2 of 5 Lessons)

4.2 INSPECTING COLLECTION SYSTEMS

Inspection of wastewater collection systems is a very important phase of the operation and maintenance of collection systems. When inspecting, look for the causes of problems or the start of a potential problem. Once a problem has been identified, its exact location must be determined. The size and kind of problem must be identified so the problem can be solved. This section outlines the kinds of problems found in collection systems.

4.21 Types of Collection System Problems

Collection system problems may be created or caused by design, construction, sewer use, operation, maintenance or outside forces or events. Major sources of problems include:

GE
COLLEC
ON SYSTEM PROBLEMS
PES
FIVE
PRO
BLEMS

1. Design-related deficiencies. Design must consider and make provisions for special local conditions such as ability of soil to support pipe and manhole weights, shifting soils, and vibrating or crushing forces from traffic. Other design-related problems include inadequate provisions for joint flexing and pipe bedding.

2. Improper installation. Plans and specifications must be followed. Improper line, grade and joint installation and short cuts in bedding, connections and backfilling can cause future problems. Other examples of improper installation include use of inferior or damaged materials.

3. Inadequate sewer-use ordinances, communication between dischargers to sewers and enforcers of ordinances, and enforcement.

4. Improper inspection and enforcement of tap-ins or service connections by individuals, plumbers or contractors that result in illegal connections and/or inflow.

5. Changing patterns of population shifts and activities that result in surcharging[1] some sections of the sewer system and excessive residence time of wastewater and solids in other sections.

6. Disaster or contingency situations such as explosions, earthquakes, war or wastewater flow shifts of major proportions.

7. Problems of a recurrent nature in the collection system such as the accumulation of grease, debris and trash that results in stoppages or restrictions that reduce the capacity of the sewer.

8. Problems characteristic of the region such that hasten the deterioration of sewers for examples, climate, high sulfate content in waters, high soil or wastewater temperatures, rapid root growth and mucky soils.

9. Poor coordination between local agencies. Street construction and repair as well as activities of other utility agencies should be coordinated. Consideration must be given to previous installations of utilities. Provisions must be made for early warnings of accidents or a workable system for handling regular dumps.

10. Problems related to a tired and frequently forgotten wastewater collection system.

Once the source or cause of a problem has been identified, provisions can be made to correct this problem and also to prevent similar problems from occurring in the future.

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[1] Surcharge. Sewers are surcharged when the surface of the wastewater in manholes is above the top of the sewer pipe. The sewer is under pressure or a head, rather than at atmospheric pressure.

QUESTIONS

4.2A What is the purpose of inspecting wastewater collection systems?

4.2B List the major sources of wastewater collection system problems.

4.22 Inflow and Infiltration

Infiltration and inflow, while overlooked in many collection systems for decades, have now gained recognition as a major defect that can cause failure of a collection system. In most cases, this failure results in hydraulic overloads (too much water) of the collection system or the wastewater treatment plant.

1. In the case of a collection system, hydraulic overloads result in surcharged manholes, manhole overflowing and exposure of a community to the diseases and pollutants carried by a wastewater collection system.

2. In the case of a wastewater treatment plant, infiltration and inflow can result in plant loads in excess of the plant capacity. By-passing raw wastewater to the environment has been the only answer in the past, but this practice is no longer allowed.

4.221 Detection and Correction of Inflow

Inflow detection and correction depend upon the type and source of inflow causing the problem. Inflow is wastewater that enters a sewer as the result of a deliberate connection.

1. Inflow

Inflow requires a combination of flow studies and an inspection of buildings or private property if they appear to be the location of the source. While closed circuit televison inspections can reveal service connections with heavy discharges of clear water, or unabated discharges not typical of a domestic waste discharge, it is a slow process. This procedure requires the camera to observe a service connection for as long as twenty minutes to determine type and quantities of flow. If a location appears to be discharging greater than typical flows, contact residents of the home or building. Determine if water use is taking place and if the use is the only source of the flows observed.

Corrections to eliminate inflow require a sewer-use ordinance rather than sewer maintenance projects. In such cases, a provision for enforcement of waste discharges to a collection system should be part of local codes or ordinances and transferred to a legal or enforcement activity, such as an industrial waste section. A wastewater collection system maintenance crew should never be required to do more than report and provide reliable proof of inflow violations by a property owner.

Where illegal inflows are detected and certified, the maintenance crew may be required to certify as to the effectiveness of possible corrections or to accurately measure flows for billing purposes.

2. Surface Drainage

Sources of surface drainage are best located by smoke testing (Section 4.5). These can partially be corrected when the collection system crew has the proper authority. On private property removal of improper connections, such as roof leaders being connected to a wastewater collection system, should be the responsibility of some agency of a municipality or district other than the collection system crew. Other sources of surface drainage include water entering the collection system through unsealed manholes located at points lower than the surrounding area grade and through broken or deteriorated pipes.

4.222 Identification and Correction of Infiltration

Infiltration is detected by metering flows in sections of the collection system to determine which area is providing the greatest flows, especially during the early morning hours when flows from residences are small. Typical flow metering devices don't work in areas where the sewers are surcharged (water in manholes over top of sewers). Under these conditions, measure depth of flow or surface of flow by measuring distance from manhole lid to surface of water to identify areas of high flow during periods of expected low flows.

After areas with high infiltration are located, field verification is required of the problem areas by visual inspection, smoke testing (Section 4.5), dye testing (Section 4.6) and/or TV inspection (Section 4.4). Visual inspection of manholes for infiltration should be performed after several storms have occurred and then during a heavy storm to confirm inflow from the suspected area. TV inspection can pinpoint the location and severity of an infiltration problem.

In many areas the main line portion of the collection system is relatively tight. A major source of infiltration in this situation can be the service lines. They can be tested for leaks using smoke testing, but the sewers can't be televised. Repair of service lines can be very expensive and complicated if the property owner is responsible for the service lines.

Correction or elimination of infiltration depends on the type and location of the source of the problem. Typical solutions to infiltration problems include:

1. Manholes
    a. Raise rim elevation by use of grade rings if not located in streets.
    b. Install water tight covers where needed.
    c. Seal covers.
    d. Seal or repair barrels.

2. Cleanouts, vents and other appurtenances.

   a. Sealing covers and/or diverting surface waters away from possible areas of entry to a sewer.
   b. Repair damages.

3. Sewer pipes.
   (See Chapter 6, Underground Repair and New Construction)

   a. Seal segment of damaged pipes and joints by pressure grouting.
   b. Dig up and replace damaged pipes and joints.
   c. Line sewer with a plastic liner.

4.223 Exfiltration

All wastewater collection systems, except some constructed in recent years, have many leaks. These systems do not exfiltrate large amounts because the solids in the wastewater plug up the soil. The very small amount that does exfiltrate does little harm unless it is close to a shallow well or open ditches where children and pets play. To make an old collection system air tight would be extremely expensive and not very cost-effective. Major points of infiltration or exfiltration in a collection system can be identified by the use of television or smoke testing and corrected.

As of this writing (1976), a federal requirement for qualification of grants of federal moneys for collection system and wastewater treatment plant construction requires a survey of the collection system. The purpose of this survey is to determine the existence or nonexistence of infiltration and inflow and an evaluation of the cost of correction in relation to the cost of constructing a treatment plant large enough to accomodate any additional flows. There are a few factors which can make the methods of a system survey both unreliable and highly costly to a community that obtains a federal construction grant.

If a collection system flow analysis shows the system conveying less than 100 gallons per person per day, the system is considered to be in good condition. The possibility that a collection system may be all above a water table and exfiltrating 100 gallons per person per day must be considered too. This exfiltration can go on until a health authority traces the source of ground water pollution to exfiltrating collection system pipes and the real trouble falls on the shoulders of a community.

The responsibility for maintenance and repair of a collection system will automatically fall on the finances of a community after a federal grant has been made and a wastewater treatment plant constructed. Required corrections to an exfiltrating collection system will have to be made by the community from its own financial resources. To protect your community from high future repair costs, air testing of lines not deemed to be infiltrating is recommended. An air test in joint-by-joint increments (Chapter 3, Section 3.7) may be used to reveal possible sources of exfiltration in areas where infiltration and exfiltration are known to be a problem.

QUESTIONS

4.2C Why must inflow and infiltration be controlled?

4.2D What are the sources of inflow?

4.2E How can sources of infiltration be located?

4.2F How can infiltration problems be corrected or eliminated?

4.2G Why should exfiltration be controlled?

4.3 INSPECTION OF MANHOLES

4.31 Objective of Manhole Inspection

Because they are part of the collection systems, manholes will require the same inspection and attention as the rest of the sewer network. When located in streets, these structures are subject to the vibrations and pounding of vehicle traffic. Manholes may settle at a different rate than the connected sewer, thus creating cracks in joints. Easement locations on private property are subject to misuse and changes of ground surface due to construction or gardening work. The objectives of manhole inspection are therefore to determine the proper elevations or grades around the lid, to be sure the lid isn't buried, and to examine structural integrity (look for cracks) of the manhole and its functional capacity.

4.32 Safety
See Section 4.1, Traffic and Manhole Safety

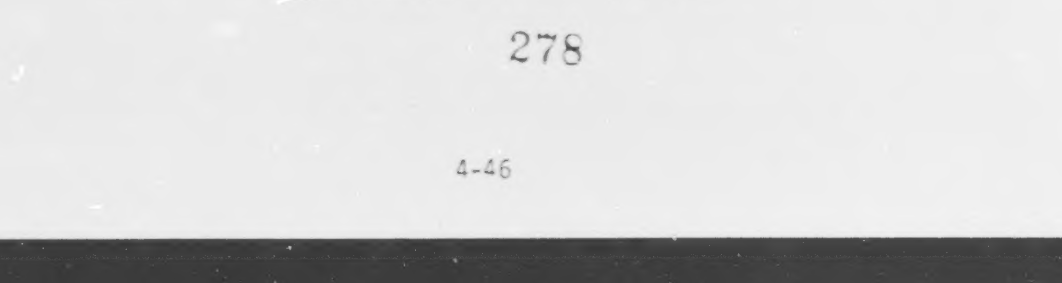
TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14

4.33 Equipment Required

1. An inspection report form which acts as both a record and a check list to make certain all types of defects or maintenance requirements are adequately noted (see typical form at end of of this section on pages 4-50 and 4-51).

2. A powerful flashlight which will permit the inspector to see down into the manhole. A mirror may be used if the sun is shining.



3. A map of the collection system to reference manhole locations on the report form.
4. A manhole lid lifter or other type of lid removal device.
5. Scrapers and wire brushes for cleaning the manhole ring.
6. A rigid straight edge approximately five or six feet long. A board, piece of pipe, angle iron or similar device will do.
7. A pair of sturdy leather gloves.
8. Where the manhole is located in traffic, a vehicle with adequate warning devices, safety cones and other traffic safety devices.
9. Where required, a metal detector and a pick and shovel to expose manhole lids which may have been buried or paved over.

4.34 Manpower

One worker is usually all that is needed. In some locations where traffic is heavy, flagmen may be necessary. In rare situations, a worker may have to enter the manhole for inspection purposes and proper manhole safety procedures must be followed (see Section 4.1, Traffic and Manhole Safety).

4.35 Procedure

The manhole inspection consists of four steps.

Step 1:

Locate manhole and check area around it for proper drainage away from the lid. The straight edge may be useful in this operation. With the straight edge, see that the manhole, if located in a street, is at the proper elevation. In areas subject to snow, a high manhole ring or lid can cause the blades of snow removal equipment to catch on it, damaging both manhole and equipment. If the lid is excessively below or above finished street grade, the manhole structure will be subject to pounding when traffic crosses. These situations should be considered defects.

In easement areas, the manhole lid should be two or more inches above the soil level around it (except in driveways, walkways or parking lots where street elevation requirements apply).

Enter any grade or elevation defects on the report form.

Step 2:

Safety: Manhole Entry.
(See Section 4.1, Traffic and Manhole Safety).

Remove the manhole lid and pull it to one side.

CAUTION

BECAUSE THE UNDERSIDE OF A MANHOLE LID CAN HARBOR DANGEROUS INSECTS SUCH AS THE BLACK WIDOW SPIDER, WASPS, HORNETS AND MUD DAUBERS. WEAR PROTECTIVE GLOVES AND EXERCISE CAUTION WHEN HANDLING MANHOLE LID.

Mark the inspection form in accordance with the configuration of the pipes entering the manhole. Be sure to write neatly and clearly so others can read your writing and understand what you observed.

With the flashlight, inspect all surfaces and joints inside of the manhole. Write on the form the location and types of any defects which may be observed such as:

1. Cracks or breaks in the walls or bottom.
2. Infiltration at any place. Estimate flow in gallons per minute.
3. Joint security. Joints in a manhole should be tight. There should not be any visible cracks large enough to allow significant infiltration or exfiltration.

4. Offsets or misalignment of any parts.

5. Root intrusions.

6. Grease accumulations around arch or inside of sewers entering and leaving manhole.

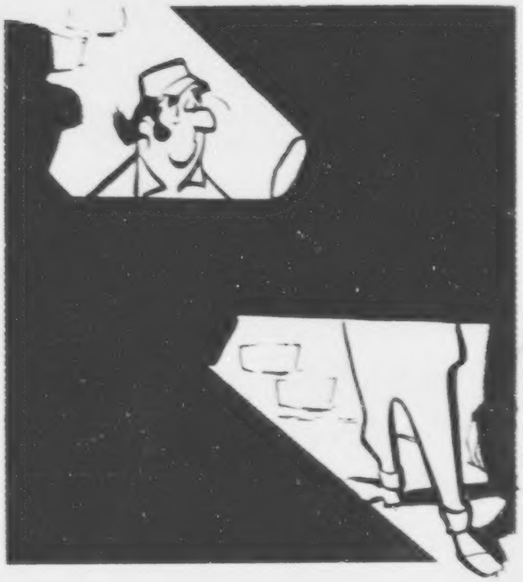
7. Gravel or debris accumulations in invert.

8. Concrete or grout in the invert or pipe causing flow turbulence.

9. Grout bed of frame.

10. Condition of steps (if provided).

11. Debris on shelf or steps.



12. Sluggish flow or wastewater backing up into the manhole.

13. Corrosion.

Where there is minimal background noise, the inspector can squat and listen for the possible noise of turbulence or squirting water. Where the pounding of traffic has driven the manhole structure as little as a quarter of an inch below constructed grade, pipes connected to it can be cracked or broken at or near to the connection point to the manhole. Infiltration or turbulence in the flow will sometimes make an detectible noise at these breaks. Look into the sewer above and below the manhole for cracks or breaks that could have been caused by settling.

When inspecting a manhole in a climate subject to ground freezing, examine the grade rings for any separation because freezing is a major cause of separation. Leaks developed at points of separation can introduce great quantities of inflow during periods of snow melt.

Step 3:

With a wirebrush and scraper, clean the ledge of the manhole ring. Inspect carefully for any cracks in the metal parts.

NOTE: ONE CRACK IN A MANHOLE RING WEAKENS THE REST OF THE METAL PART, THUS POSSIBLY RESULTING IN SUDDEN FAILURE UNDER A VEHICLE LOAD.

If a crack is observed, the manhole should be barricaded and the ring should be replaced immediately.

Step 4:

Replace the manhole lid. Look for evidence of a warped or misfit lid by standing at various positions around the lid. The lid should not rattle or "rock". Where traffic passes over a lid with a rattle, the noise and rattle will increase with time. Make certain that the ring is clean and does not have a pebble or other object preventing proper fit before recording a rattle as a defect. A rocking or improperly seated manhole can be flipped completely out of the ring by a vehicle driving over the cover.

Defective manhole lids and rings can be removed and machined, or milled in place with special equipment, or replaced. Gaskets may be used to reduce rattles, but gaskets have to be replaced periodically.

4.36 Frequency of Manhole Inspections

Any new manhole should be carefully inspected before acceptance in the same manner as the rest of the pipe system. Existing manholes should be inspected once every one to five years with those in areas of heavy vehicle traffic being inspected more often. If you are inspecting manholes and discovering many serious defects that need correcting, then the manholes should be inspected more frequently.

When a crew working in a manhole for other than manhole inspection (rodding, cleaning, television) discovers a defect, a written report or completion of a manhole inspection form should be prepared so the manhole will be repaired.

4.37 Sample Inspection Forms

A sample form blank and a form with notations on the next two pages show how to record data from a manhole inspection.

QUESTIONS

4.3A Why should manholes be inspected?

4.3B How many workers are usually needed to inspect a manhole?

4.3C What items should be examined when inspecting a manhole?

4.3D How often should a manhole be inspected?

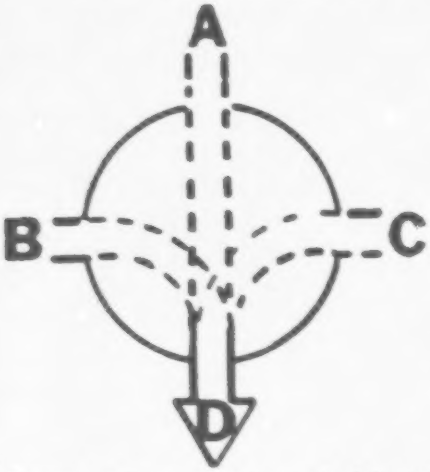
END OF LESSON 2
OF 5 LESSONS
ON
TESTING & INSPECTING
COLLECTION SYSTEMS

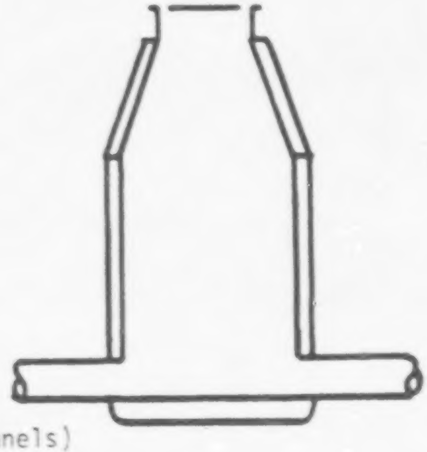
MANHOLE INSPECTION REPORT

MH NO.________________ DATE__________ TIME_________ INSPECTOR______

ELEVATION__________ DEPTH TO INVERT__________ CLEANLINESS___________

TYPE CONSTRUCTION_____________ STREET REFERENCES______________________





DEFECTS:
(Cover, frame, grout, steps, shelf, pipes, or channels)

1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

8. ____

(USE REVERSE SIDE FOR ADDITIONAL DEFECTS TO BE NOTED.)

	PIPE SIZE	LENGTH	TO MH#	EST. FLOW	TYPE FLOW
A-					
B-					
C-					
D-					

REMARKS:
(Include need for repairs)

____

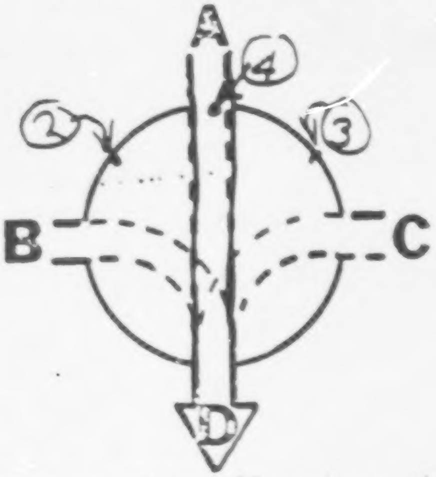
____

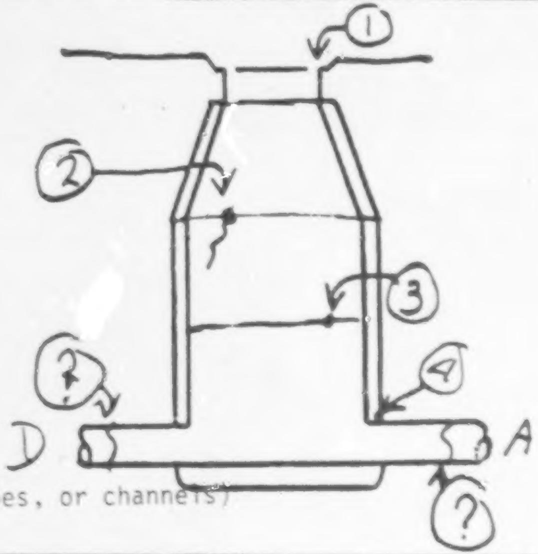
MANHOLE INSPECTION REPORT

MH NO. 6822 DATE 7-20-74 TIME 10:15AM INSPECTOR J.S.

ELEVATION ______ DEPTH TO INVERT 9'7" CLEANLINESS OK

TYPE CONSTRUCTION CONC-CAST STREET REFERENCES 34 AVE & AITKIN





DEFECTS:
(Cover, frame, grout, walls, steps, shelf, pipes, or channels)

1. MH RING DEPRESSED 1¼"
2. DIAGONAL CRACK IN BARREL
3. SEAL FAILURE AT JOINT - 1-GPM LEAK
4. SEAL FAILURE & PIPE CRACK - 2-GPM LEAK
5.
6.
7.
8.

(USE REVERSE SIDE FOR ADDITIONAL DEFECTS TO BE NOTED.)

	PIPE SIZE	LENGTH	TO MH#	EST. FLOW	TYPE FLOW
A-	8	275	6823	2"	SOAPY
B-					
C-					
D-	8	320	6821	2"	

REMARKS:
(Include need for repairs)

AUDIBLE LEAK(S) IN PIPES NEAR MANHOLE. DEPRESSED RING MAY INDICATE DROP JOINTS OR BREAKS IN LINE.

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 2 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

7. Why must wastewater collection systems be inspected?
8. What happens when there is inflow and infiltration in a collection system?
9. What can be done to correct or eliminate inflow and infiltration problems?
10. Why should manhole lids be the proper elevation?
11. How would you inspect a manhole?

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 3 of 5 Lessons)

4.4 CLOSED CIRCUIT TELEVISION INSPECTIONS (CCTV)

Television inspection of a sewer provides positive and reliable answers to what, where, how bad, and how much in a way that has never been possible before. Conjecture, guesswork, and wild estimates of the past, representing many thousands of dollars wasted in unnecessary pipeline replacement work or excavation repairs, that were made at the wrong place or were not really necessary, are overcome with a closed circuit television inspection.

In the words of one worker who had made a careful study of operational and repair costs to a moderately sized system, comparing expenditures before and after acquisition of a closed circuit television outfit, "BEFORE TELEVISION, WE WERE LIKE BLIND UMPIRES TRYING TO CALL A BASEBALL GAME. WE HAD AN IDEA OF WHAT WAS GOING ON AND WHAT WAS NEEDED AND DID WHAT WE THOUGHT WAS THE RIGHT THING TO TAKE CARE OF THE SYSTEM. THAT WE MADE SOME PRETTY COSTLY MISTAKES IS A MATTER OF RECORD, BUT WE REALLY DIDN'T KNOW HOW BAD THAT RECORD WAS UNTIL THE TELEVISION SHOWED US THE TRUTH. IF THERE IS ONLY AS LITTLE AS FIVE MILES OF SEWER SYSTEM, TODAY'S REPLACEMENT COSTS WILL EXCEED A HALF-MILLION DOLLARS. INADEQUATE MAINTENANCE, POOR QUALITY REPAIRS, AND ALLOWING PROBLEMS TO REACH EMERGENCY STATUS WILL, IN ADDITION TO CAUSING UNREASONABLY INCREASED COSTS OVER THE YEARS, HASTEN THE DATE WHEN FULL REPLACEMENT IS NECESSARY. THE ENGINEERS, SUPERINTENDENTS, AND OTHER OFFICIALS WHO ATTEMPT TO MAINTAIN

SUCH A SYSTEM WITHOUT THE POSITIVE KNOWLEDGE FROM REGULAR TELEVISION INSPECTIONS ARE LIKE WE WERE BEFORE WE ACQUIRED OUR TELEVISION EQUIPMENT - - BLIND, IGNORANT, AND A HEAVY TAX BURDEN TO OUR COMMUNITY."

Up to the end of 1974, it is estimated that over one thousand cities and districts in the United States owned closed circuit television equipment for sewerline inspection. An additional twenty-five hundred are known to have rented equipment or contracted to have CCTV inspections made in their systems. Like the words of the worker in the previous paragraph, a great majority of people concerned with the construction, design and maintenance of the sewer lines were astounded as well as somewhat embarrassed by the facts revealed by CCTV inspection. As a result, many long-standing and formerly accepted concepts of engineering design, construction methods and system maintenance procedures are in the process of drastic revisions or replacement.

These results and changes make the use of closed circuit television in collection system inspection and evaluation work applicable to all public and private wastewater collection system agencies in the very near future. The size or length of the total system is not expected to have any effect on the urgency and economical requirement of such inspections. Because smaller agencies and collection systems will usually have limited financial capacities, the importance of the precise and accurate data on sewer conditions, performance of required work and the priority of such work can justify the use of CCTV to avoid the catastrophic burdens of many emergencies. It is a recognized fact that smaller systems usually have higher costs for contract emergency work, and this type of work results in losses that take away a heavier percentage of available financial assets. Larger systems with the opportunity for many problem areas should have no problem in recognizing the advantages of and vast savings from the ability to program manpower, equipment and funds for maximum utilization in system requirements.

Whether a CCTV system is owned, leased, or rented or the work is contracted out, workers employed to maintain wastewater collection systems need to know how the CCTV equipment works and the information it can provide. This section covers the operational phase of closed circuit television inspections of wastewater collection system pipes. Details on components comprising a television system can be found in the Appendix of this chapter, Section 4.9, Closed Circuit Television Equipment Details.

4.41 Use of Television

A closed circuit television (CCTV) inspection consists of pulling a special television camera through the sewer. The picture sent by this camera is observed on a monitor similar to a home television screen. This picture allows a visual inspection of the interior of the sewer.

TV cameras can be used to inspect sewers from 4 inches in diameter up to approximately 48 inches in diameter. Usually sewers larger than 48 inches are inspected by a collection system worker and TV is used in sewers that are too small for a worker to enter.

4.411 Purposes of Televising Collection Systems

A television inspection of a collection system can be conducted for the following reasons:

1. Inspect conditions and determine location of problem areas such as pipe or joint separations, drops, ruptures, leaks, service connections, obstructions, corrosion, pipe alignment, and root intrusion.
2. Look for damage to sewers caused by excavation and construction on nearby utilities, paving and building construction.
3. Search for unrecorded connections that may reveal illegal taps, such as industrial, storm water, or surface drainage.
4. Locate inflow or infiltration sources and amounts.
5. Inspect installed and/or repaired taps or pipes by plumbers, contractors or maintenance crews.
6. Evaluate effectiveness of solutions and equipment in maintaining or correcting problem areas in sewers.

4.412 Actions Possible from CCTV Inspection Information

From the information obtained by a closed circuit collection system inspection, all of the following actions are possible:

1. Require contractor or construction agency to correct defects observed in new sewers prior to acceptance.
2. Identify or verify exact locations of service connections and other pipe construction points and correct any as-built maps as needed.
3. Establish priorities for corrective work in old pipes on an 'as needed' basis.
4. Provide for maximum effective and economical use of manpower and equipment for a preventative maintenance and repair program covering an entire collection system.
5. Inspect construction of house service connections to the lateral and branch sewers. Determine by observation of these connections if infiltration, roots, debris accumulations and/or some types of internal inflow are adversely affecting the capacity of the sewers.

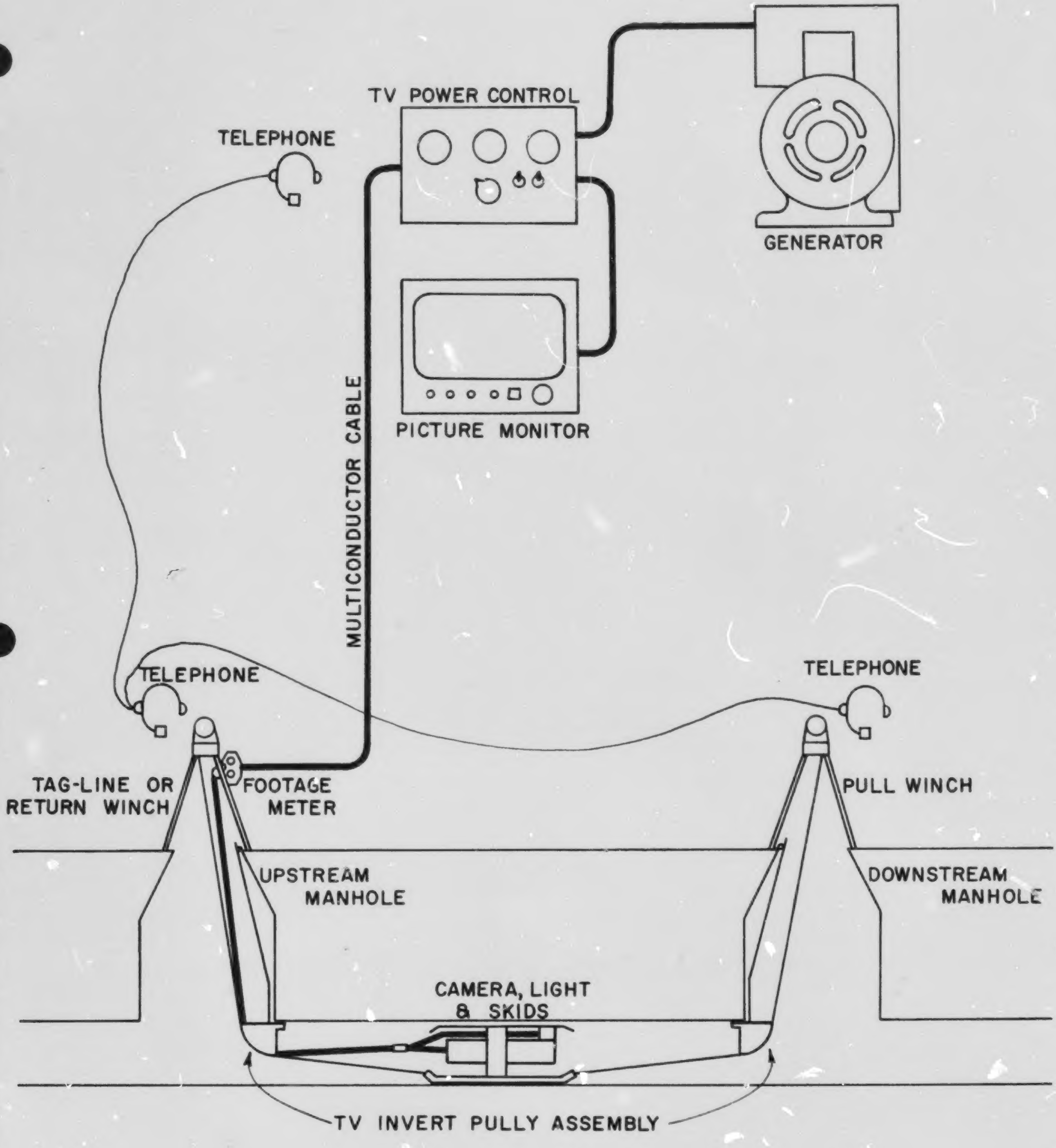
4.42 Equipment and Manpower

NOTICE

Technology is rapidly advancing throughout the wastewater collection system field. Industry is striving to help us do our job safer, faster, better and at a lower cost. You must realize that equipment, manpower and procedures described throughout this manual are presented to give you an idea of the types of equipment available, manpower needed, and the kind of procedures necessary to do the job properly and safely. When you read this material, recognize that there are other pieces of similar equipment that might have slightly different manpower requirements and/or operational procedures. For example, TV survey equipment is available today that is so light and compact that you could haul it around in a van, station wagon or pickup and remove it from the vehicle when the vehicle is needed for another purpose.

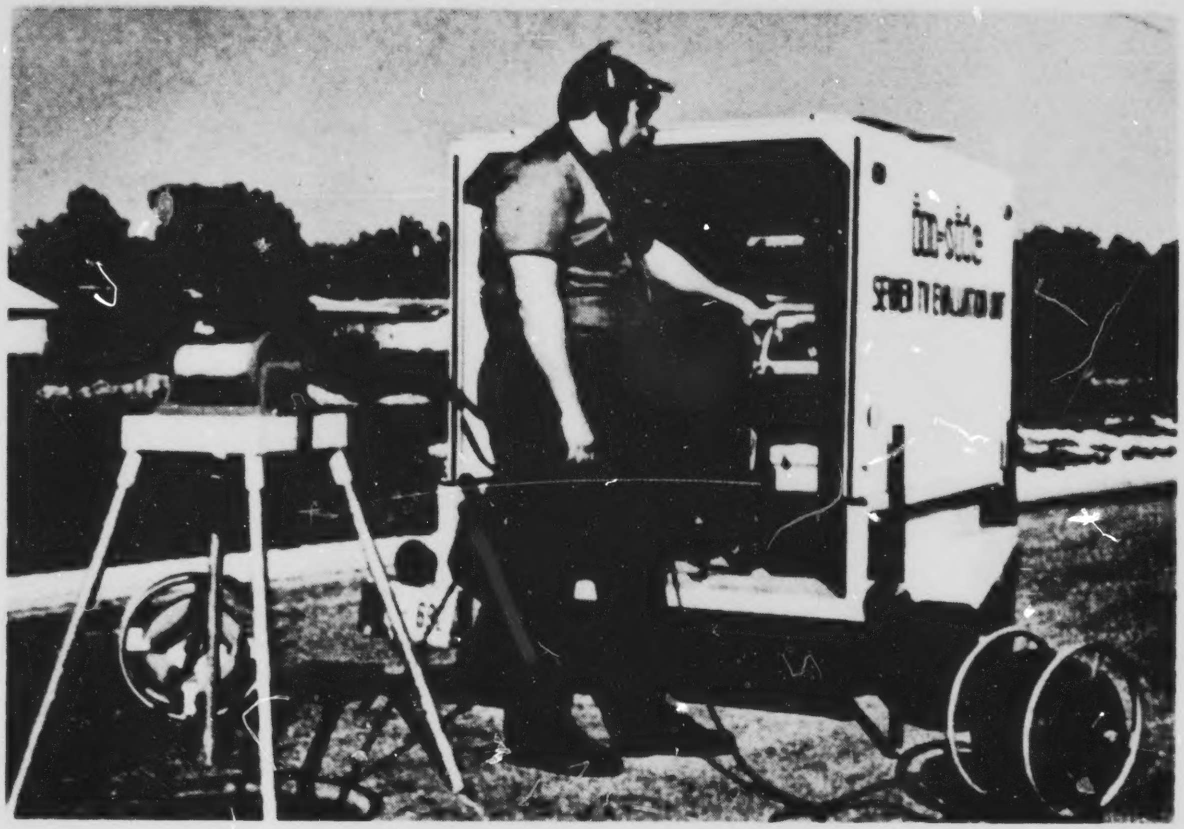
4.421 Equipment and Components Required for Televising

Essential components for televising sewers are listed in this section. Figures 4.7 and 4.8 show a typical set up and Figures 4.9 and 4.10 are photos of some of the components.


TV POWER CONTROL
TELEPHONE
GENERATOR
PICTURE MONITOR
MULTICONDUCTOR CABLE
TELEPHONE
TELEPHONE
TAG-LINE OR RETURN WINCH
FOOTAGE METER
PULL WINCH
UPSTREAM MANHOLE
DOWNSTREAM MANHOLE
CAMERA, LIGHT & SKIDS
TV INVERT PULLY ASSEMBLY

NOTE: Use sound-powered telephone communication system.

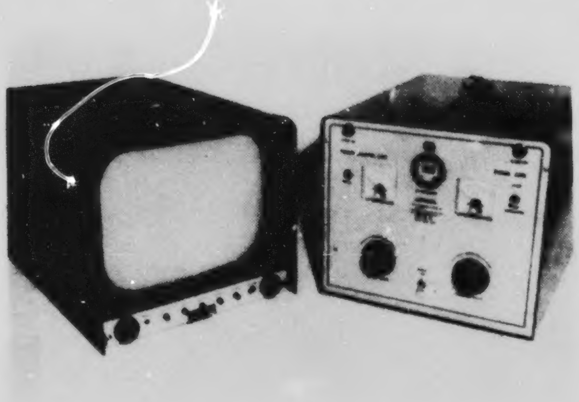
Fig. 4.7. Set up of basic TV system



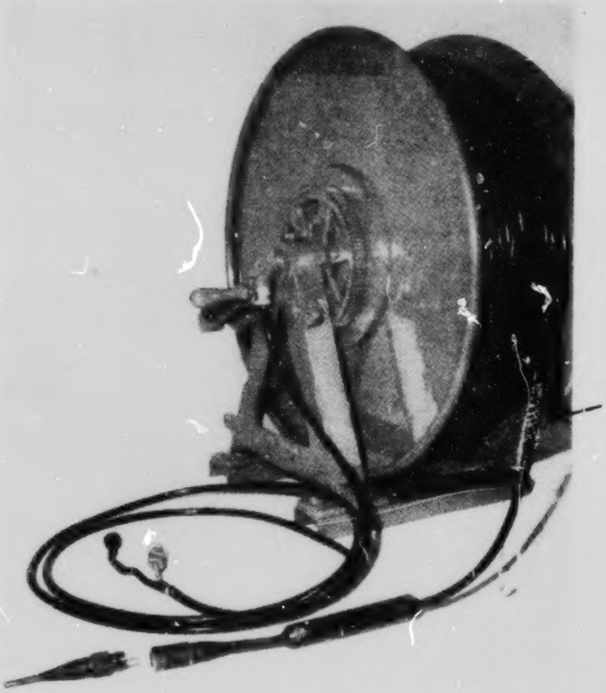
SEWER TV EVALUATION UNIT

Float line and reel are behind tag line (return) winch. Footage meter can be seen behind right knee of operator. Telephone cable and reel are to the right.

Fig. 4.8. Small trailer mounted CCTV system (Courtesy of Cues)

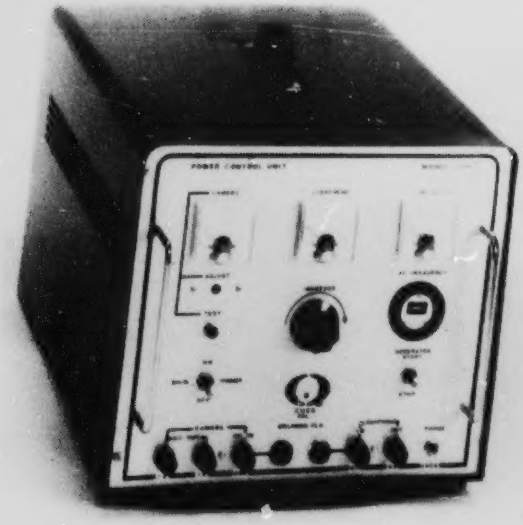


Industrial television monitor and CCTV power and light control module.

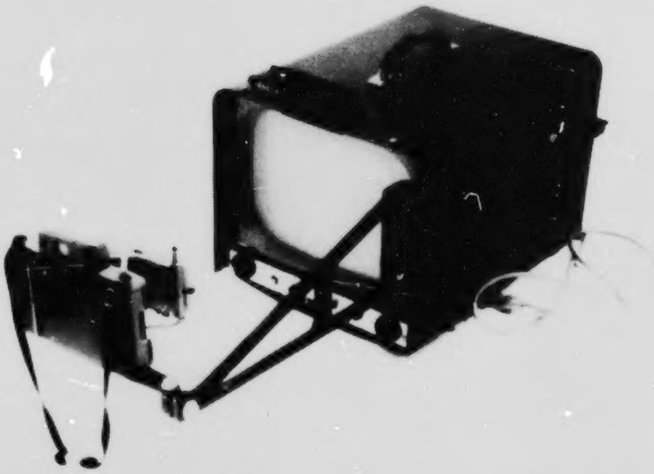


Typical multiconductor cable reel showing terminal hardware and connections to CCTV cable. Note Chinese finger-trap type of cable strain relief to keep stress from electrical connections.

Fig. 4.9. Television monitor, power and light control module and multiconductor cable reel



Television power control module



Television picture monitor with footage meter (on top) and Polaroid camera

Fig. 4.10. Essential TV system components (Courtesy of Cues)

1. Television camera.
2. Camera light.
3. Multiconductor power and video cable. (Figure 4.9)
4. Television picture monitor (screen). (Figure 4.10)
5. System power control center or module. (Figure 4.10)
6. Portable power source.
7. Camera carrying skids. (Figure 4.11)
8. Camera pulling winch.
9. Camera return winch.
10. Footage counter. (Figure 4.11)
11. Fair lead pulleys and hardware.[2]
12. Sound-powered telephone communication system.
13. Float line or pipe stringing line.

Other items, not essential to televising the sewer, but capable of saving time, useful and protective to the equipment and the work to be done include:

1. Television cable reel with slip rings.
2. Video tape recording equipment.
3. Video footage readout. (Figure 4.12)

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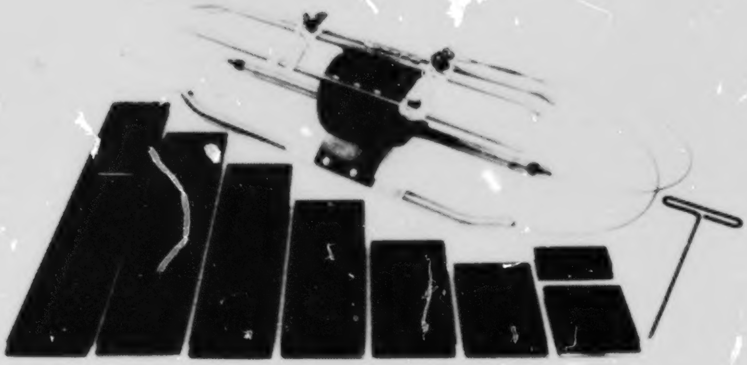
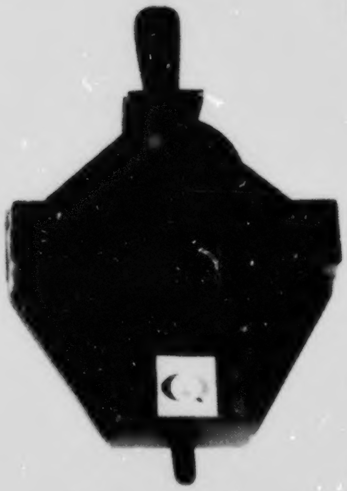
[2] Fair lead pulley. Pulley placed in manhole to guide TV camera through pipeline.



TV camera skid outfit with spacer plates for various sizes of pipes



Television cable footage counter wheels

Fig. 4.11. Essential TV system components (Courtesy of Cues)

Date	7-12-74
Job No.	000003
Footage	143.4 +
Air Test	00.0 psi

+ indicates camera is looking downstream

NOTE: Infiltrating Joint

Fig. 4.12. Polaroid photo of TV Monitor

4. Enclosed trailer or van to contain TV equipment, records, and maps.

5. Polaroid camera to take pictures of sewer shown on TV monitor.

6. Usual tools and equipment required for safe manhole work (see Section 4.1, Traffic and Manhole Safety).

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14

4.422 Manpower

Usually the televising crew consists of three workers:

1. TV System Operator,* Wastewater Collection.
   An 'operator' who observes the monitor and controls the

---

* Job titles in this manual are consistent with "Standard Occupational Titles." For details regarding job titles see "Manpower Requirements for Wastewater Collection Systems," by Elie Namour for U.S. Environmental Protection Agency, Office of Water Program Operations, Washington, D.C., 1973.

progress of the operation. This worker is the crew leader.

This operator must be an experienced collection system worker who has inspected and repaired sewers. This worker has to be capable of recognizing problems that appear on the TV monitor. Collection system workers can learn to operate the TV equipment quickly and easily. The operator must know how to insert the TV equipment into the sewer and how to remove the equipment. Also the operator must be capable of recognizing TV equipment problems. A knowledge of TV electronics is not required, but the equipment must be properly used and maintained, especially the connections and connectors.

2. Maintenance Man I, Wastewater Collection
   A pulling winch worker to cause the camera to be pulled through the sewer.

3. Maintenance Man I, Wastewater Collection.
   A return winch worker who operates a return winch to pull the camera backwards and to wind the transmission cable back as necessary. Essential for safety purposes, but return winch worker not needed with some TV equipment.

4. Additional help may be needed when working in heavy traffic and congested areas.

QUESTIONS

4.40A Why must testing and inspecting collection systems be done thoroughly and on a regular basis?

4.40B What are the advantages of closed circuit television inspection of wastewater collection systems?

4.40C List the kinds of information that can be obtained from a television inspection of a sewer system.

4.40D How many people are usually on a collection system televising crew?

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4.43 Procedure

4.431 Setting Up a CCTV Operation

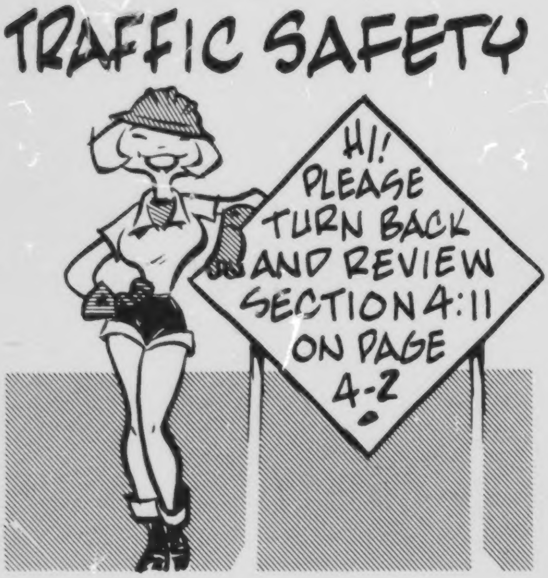
In this example procedure, the TV camera will be used to inspect a sewer between two adjacent manholes. The camera should always be pulled in the direction of flow or from the upstream manhole to the downstream manhole for the sake of consistency. Although the TV camera could be pulled in either direction in new pipe, all records must be kept and footage measured from the upstream manhole to the downstream manhole. If footage is measured from different directions, other repair crews could become confused and dig in the wrong location for a bad joint or tap. By moving a camera downstream, any debris in the pipe should be washed away from the front of the camera and any build up on the back of the camera should be removed as the camera moves along.

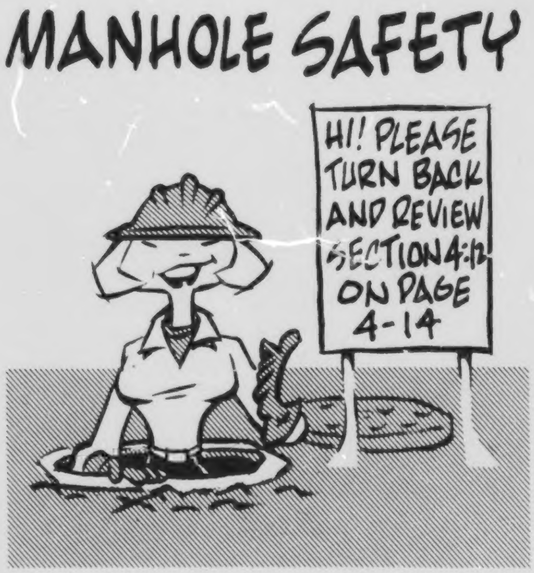
Usually sewers are cleaned by balling (Chapter 5, Section 5.21), with a high velocity cleaner (Section 5.22), or with a power rodder (Section 5.32) before televising to remove grease, roots or debris that could interfere with the operation of the TV camera or inspection of the sewer such as covering cracks, leaks, and open joints. Some agencies string lines using a parachute that helps to clean a sewer before televising. Whether or not a sewer should be cleaned before televising depends on the diameter and condition of the sewer. Cleaning gets rid of obstructions, thus allowing better flow conditions, or identifies the location of obstructions that could cause problems during TV inspection.

If the sewer to be televised is flowing so full that the TV camera will be submerged, the upstream line will have to be plugged during the televising operation. After stringing the sewer and when you are ready to start televising, plug the sewers flowing into the upstream manhole. Be careful that the wastewater held behind the plugs does not back up into someone's home or flow out the top of a manhole. Also the plugging of sewers will cause downstream flows and conditions to change which could interrupt downstream flow measurements, sampling, tests, and wastewater treatment processes; therefore, always notify treatment plant operators and industrial waste inspectors whose activities could be affected by your actions.

The following sections contain typical steps that should be followed to inspect a sewer using closed circuit TV. ALWAYS FOLLOW THE DIRECTIONS PROVIDED BY THE MANUFACTURER OF YOUR TV EQUIPMENT.

1. Safety. Refer to Section 4.1, TRAFFIC AND MANHOLE SAFETY, for safe procedures to route traffic around job site and enter a manhole.

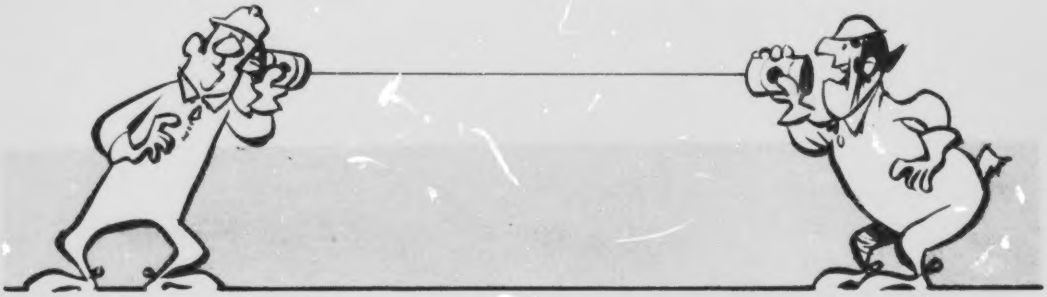

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2


MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14

2. String the sewer from mannole to manhole. The objective is to bring the pull winch cable from the downstream manhole, through the sewer, to the upstream manhole. Any method of doing this is satisfactory. Where there is adequate flow a rope, called a 'float line', is used. This rope is a quarter inch or slightly smaller in diameter and is 'floated' down the sewer with a parachute, balloon, plastic jug or other floatable object. The float line is tied to the object and the flow is used to carry the object and the float line to the downstream manhole. If flows are low or there are dips in a sewer or a partial obstruction, a high velocity cleaner or power rodder can be used to "string the line".

3. While the line is being strung through the sewer, the pull winch is moved to the downstream manhole and set up.

4. When used, the telephone cable and system are laid out from manhole to manhole and a worker at each manhole puts on a telephone headset. Voice communication is tested to make certain communications between manholes are adequate.



5. Also while the line is being strung, the generator is started and the system tested for adequate power in volts and for proper cycles (Hertz)[3] of the power supply. Most systems operate on a voltage range of 110-125 volts and 60-cycles per second (Hertz) (59-61 range) of AC (alternating electrical current). Meters indicating both of these power values are generally included in the power control module.

   a. If voltage is too high or too low, the control module should have a multiple tap transformer with marked settings to increase or decrease the voltage input to the system.

   b. Keep the generator tuned and set by experienced generator technicians to avoid problems.

---

[3] Hertz (Hurts). Number of complete electromagnetic cycles or waves in one second of an electrical or electronic circuit. Also referred to as the frequency of the current. Abbreviated HZ.

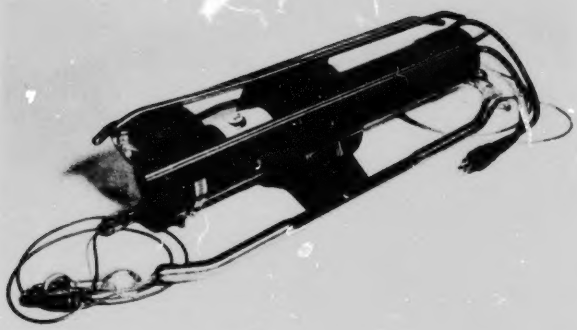
6. As soon as the power generator has been started, inspected and adjusted as necessary for proper power supply, the operator must turn off the master switch of the power control unit or such switches as are provided to the camera circuit and lighting circuit.

7. The operator makes necessary changes on the camera skid assembly to prepare the assembly for the size of pipe to be televised. The proper skid assembly is important because the TV camera lens must be as close as possible to the center of the pipe when the camera moves down the pipe. Connect the tow and tag line bridles at this time (Figure 4.13).

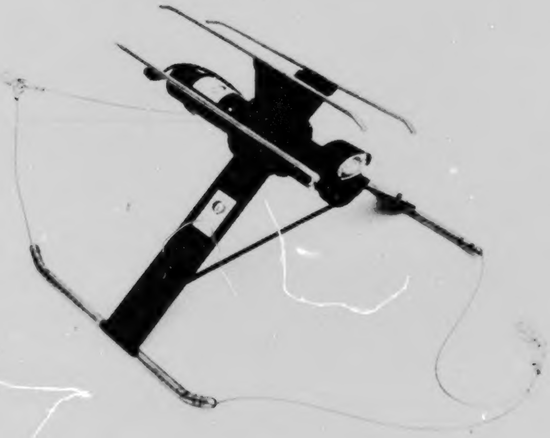
8. The operator brings the end of the television transmission cable into the location where both the front of the camera and the television monitor can be seen. The lens cover is removed from the camera. Protection of the camera lens depends on the type of tube. Silicon tubes do not need to be protected from sunlight or bright light while vidicon tubes must be protected.

CAUTION: NEVER PLACE AN EXPOSED CAMERA LENS WITH A VIDICON TUBE WHERE BRIGHT LIGHT OR SUNLIGHT CAN ENTER IT. THE OPTICAL LENS IS FOCUSED DIRECTLY ONTO THE PHOTO-SENSITIVE COATING OF THE VIDICON TUBE AND DIRECT SUNLIGHT CAN CAUSE BURNING WITH PERMANENT DAMAGE. CONSULT MANUFACTURER'S MANUAL OF INSTRUCTIONS BECAUSE SOME TYPES OF CAMERAS CAN BE DAMAGED BY BRIGHT REFLECTED LIGHT.

9. The operator connects the leads of the television transmission cable to the camera and turns on necessary switches to activate the camera power and video circuit, including turning on the televison monitor. Do not activate the camera lighthead circuit, but make certain that it is off or set to zero on the intensity control.



TV camera ready for a small line



TV camera ready for 24-inch sewer

NOTE: Tow and tag line bridles attached to lower skids.

Fig. 4.13. Sewer line TV cameras ready for operation

10. As soon as a picture appears in the monitor, the operator focuses the camera for a pre-set distance, dependent upon the diameter of the sewer to be televised. Focus the camera on an object at a distance of twice the diameter of the pipe being televised from the camera.

    a. Sewer inspection television cameras are provided with various types of wide-angle lenses, ranging from 33°, 53°, 64° and 90°. Each one of these different wide-angle lenses works with a different focal distance in any selected pipe size. A 90° lens has a picture edge only eight and a half inches away in a 12-inch pipe. In the same pipe, a 33° lens must look almost two feet down the pipe before a picture is available.
    b. Where such distances are unknown, consult the manufacturer's instructions.

11. As soon as the camera has been focused, the operator sets the camera light control and activates the lighting circuit. Bring the light intensity up only as far as necessary to enable observation of a slight glow in the lamp filament. Turn off all power to the camera.

    The lighting circuit only should be tested and turned off before any heat can develop in the light head.

12. The operator replaces the lens cover on the camera.

13. Making certain that all power to the camera assembly is off, the operator takes the camera to the manhole where the television inspection run is to start.

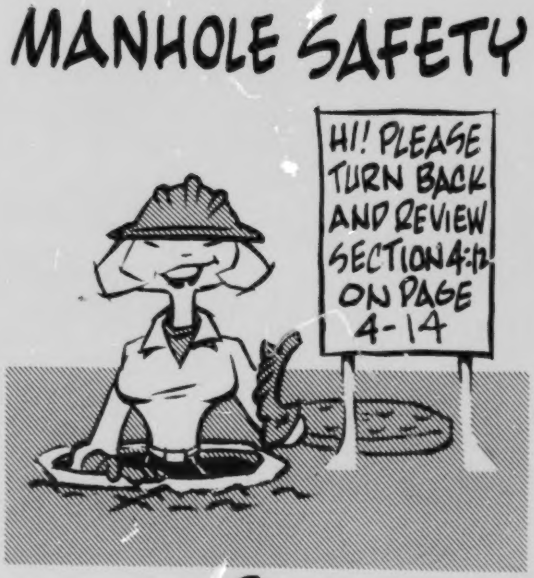
    Attach the cable strain relief to the tag line bridle and keep the electrical connections intact.

14. At the manhole, the assistant operator (Maintenance Man I) should have completed stringing the line with the float line and have pulled the end of the pull winch cable to the upstream manhole.

    a. In floating a pipe run, the pull winch worker (Maintenance Man I) announces when the float or end of the rope reaches the downstream manhole. Pull the float or rope out, usually using a hook or tong device, rather than entering a manhole, and tie the rope to the end of the pull winch cable.

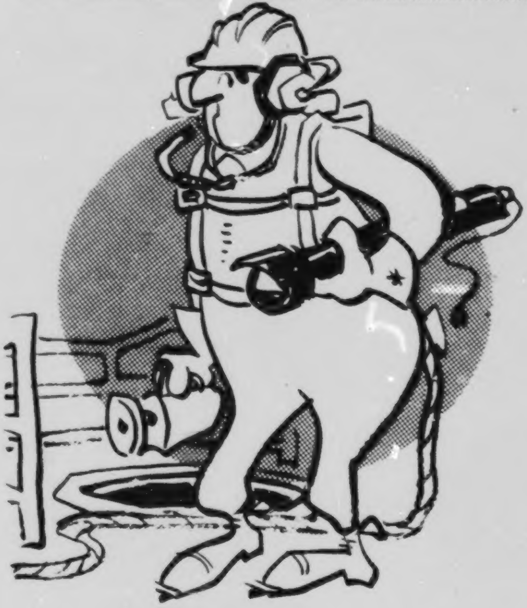
b. The operator then tells the person (Maintenance Man I) at the upstream manhole to "Pull Away", after making certain that the brake or ratchet of the winch is in the correct position to allow the cable to unwind.

c. When pulling cable off a winch, a drag system should be used to prevent an over-run of the drum, resulting in an opportunity for the winch cable to tangle or foul.


MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4.12 ON PAGE 4-14

15. At the manhole of camera entry, the assistant operator will have made necessary preparations to enter the manhole. This will include wearing the safety harness, the venting of the manhole and the testing of the atmosphere. Worker topside at manhole wears a telephone headset for communications with the pull winch worker.

Many times the TV camera can be inserted in the sewer while the crew remains topside. The camera is placed on the skid assembly and lowered into the manhole using the pull cable. Also the camera is positioned using pull cables.



16. As soon as the assistant is down in the manhole and ready, the operator passes the camera assembly down to the worker.

a. The assistant connects the pull winch line to the tow bridle and checks the attachment of the transmission cable, the proper hook up of the cable strain relief[4] and the connection of the tag line winch.

b. The assistant then removes the lens cover from the camera and with the lens pointed towards the bottom of the manhole, next directs the pull winch worker to take in slack.

c. As the pull winch cable slack disappears, the assistant lowers the camera assembly, lens end first, into the invert of the manhole and allows the pull winch to pull the camera into the pipe until the tips of the rear skids are even with the outlet of the pipe. The assistant stops the pull winch by voice command.

d. If the assistant is in the manhole, the assistant waits for the operator to indicate that the TV camera is operating properly. If the camera doesn't work, be sure the lens cap has been removed and there are no loose connections. Be sure the power is OFF before inspecting the connections, cables and TV camera.

17. Once the assistant is out of the manhole, the operator returns to the operating station and opens necessary switches to power the camera and light. As soon as the picture and the lighting are satisfactory, the operator announces that all is ready.

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[4] Cable strain relief. A mesh type of device that grips the cable to prevent any strain on the power cable from reaching the connections to the camera and the light.

18. When the operator indicates that all is ready, the pull winch worker and the assistant install necessary fair lead equipment in the two manholes and locate the winches over the manholes.

   a. As each worker completes the fair lead installation, they report their readiness to the operator.
   b. The operator is then cleared to tell the pull winch worker to pull away.

NOTE

FAIR LEAD EQUIPMENT IS NOT INSTALLED UNTIL THE OPERATOR HAS A SATISFACTORY PICTURE OF THE PIPELINE. IN SOME TYPES OF CAMERAS, AN IRIS OR F-STOP ADJUSTMENT MUST BE MADE TO THE CAMERA LENS AFTER INSIDE PIPE LIGHTING HAS BEEN TESTED. THIS SHOULD BE DONE BEFORE INSTALLATION OF FAIR LEAD EQUIPMENT AT THE UPSTREAM MANHOLE.

CAUTION

THE CAMERA MUST **NEVER** BE TOUCHED IN A MANHOLE **UNLESS ALL POWER HAS BEEN SWITCHED OFF.** SOME OLDER STYLE CAMERAS HAVE A CASE GROUNDING CIRCUIT WHICH COULD CAUSE EXTREMELY HIGH VOLTAGE IN THE CASE IN CERTAIN TYPES OF MALFUNCTIONS

19. Slack in the power cable is pulled back through the footage meter and the footage meter set for proper reading. All footage readings must be estimated as closely as possible and should always start at the center of the manhole so repair crews will always measure from the same point. Since the TV camera has been inserted into the sewer and is ready to move down the line, it may be located two or three feet downstream from the center of the manhole. This distance must be closely estimated and the footage meter properly adjusted (Figure 4.14).

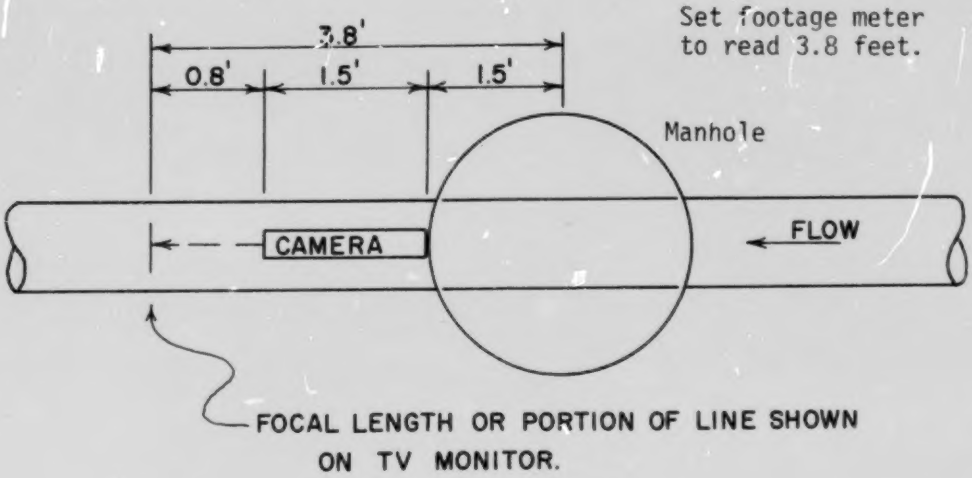


Fig. 4.14. Adjustment of footage meter

20. When all is ready, the operator directs the worker at the pull winch to pull the camera. For directions, certain commands are agreed upon ahead of time. These can be determined to direct the proper operation of the winches. The following commands are provided only as suggestions:

    a. "GO AHEAD" from the operator at the monitor means for the camera to be winched through the sewer at regular speed. This speed in feet per second or minute will vary with the experience of the operator.

b. "AHEAD SLOW" or "SLOWLY" means to reduce the speed of the camera's progress. This is generally done when some object is being approached and it may be desirable to stop for a polaroid photo or operation of the video recorder.

c. "STOP" means exactly that. The pull winch worker stops pulling.

d. "WE ARE GOING TO PULL BACK ______ FEET" means that the tag line winch is going to be used to pull the camera backwards. The pull winch worker must be advised of this action. The worker must remove the crank from the pull winch and shift the rachet (if the winch is so provided) to permit cable to be pulled backwards. Pulling back without letting the winch worker know can cause the crank to rotate rapidly, possibly striking the worker's hands or arms and causing pain or injury on certain types of equipment.

WE AREGOING
TO
BACK
FI
FEET

e. "WE ARE TAKING THE CAMERA BACK" means the camera is going to be pulled back out of the line.

CAUTION: WHENEVER PULLING A CAMERA BACK MORE THAN ONE FOOT, THE SLACK MUST BE TAKEN OUT OF THE POWER CABLE WHILE THE CAMERA IS MOVING BACKWARDS. FAILURE TO DO THIS CAN PERMIT THE POWER CABLE TO BECOME TANGLED WITH THE CAMERA AND SKID ASSEMBLY AND CAUSE EXCESSIVE WEAR POINTS AND POSSIBLE SEVERE DAMAGE TO THE POWER CABLE ON CERTAIN TYPES OF EQUIPMENT.

21. There are two essential rules that must never be violated:

   a. While the camera is being moved through the line, the operator must never stop looking at the monitor picture. Any obstruction that could wedge or damage the camera or the light must be seen in time to stop the camera's forward progress. If the picture is lost for any reason, the forward progress of the camera must be stopped. If the picture cannot be reestablished again, the camera must be pulled backwards out of the line.
   b. If communications with the worker at the pull winch are lost, progress must be stopped immediately. For most crews, a shouted signal from one member indicates a loss of this communication.

22. If the pull winch worker finds the drag on the cable is heavy, this fact should be reported to the operator. Wedging is often possible when a heavy drag occurs. Pull a camera back a few feet to see what could cause the drag or possible wedging. An out of round pipe can cause wedging. If a camera and skid assembly become locked or wedged in a pipe and the pull cables break, the sewer must be dug up to recover the camera.

QUESTIONS

4.43A Why should the TV camera always be pulled from the upstream to the downstream manhole?

4.43B What should a TV inspection crew do first when they arrive at a sewer to be inspected with a TV camera?

4.43C Is the TV pull winch located at the upstream or downstream manhole?

4.43D Why must the proper skids be used with the TV camera?

4.43E How is the pull winch cable kept from rubbing on the pipe at the downstream manhole?

4.43F Where in the pipe line should the footage meter be set to read zero?

4.43G What are two essential rules that must never be violated while the camera is moving through the line?

4.43H Why must extreme care be taken to prevent the TV camera from becoming wedged in the pipe?

4.432 Logging and Recording Television Inspections

A television inspection of a pipe line requires that all data are observed and recorded. The operator of the TV monitor must determine what is to be recorded, photographed, or video taped. As an operator you also should have the camera's progress halted every time you take your eyes off the monitor to record information.

1. Most television records are placed on a standard log (see sample on Fig. 4.15). Information that must be recorded in the log include sewer section being televised, date, name of viewer and other important facts and conditions. Coded initials and symbols or numbers are used for simplicity and to save time. Some of the suggested codes are :

   - SC Service connection. Quadrant number of position of entry is usually added. (See Figure 4.15, sample log).

   - R Roots. Generally followed by number indicating growth. (See Figure 4.16, root rating chart).

   - I Infiltration. May be followed by number to indicate estimated gallons per minute and a quadrant number to show point of entry. To learn how to estimate infiltration flows, if possible, observe typical flows at locations or in a lab where actual flows can be measured. By comparing estimated flows with actual flows, accurate flow estimates can be made by experienced workers in the field.

   - DL-G Dirty Line, grease or soap cake. For sand or silt deposits DL-S, for rocks DL-K.

   - C/B Cracked or broken place. This can have a remark indicating possible collapse of the pipe for extensive damage of this type.

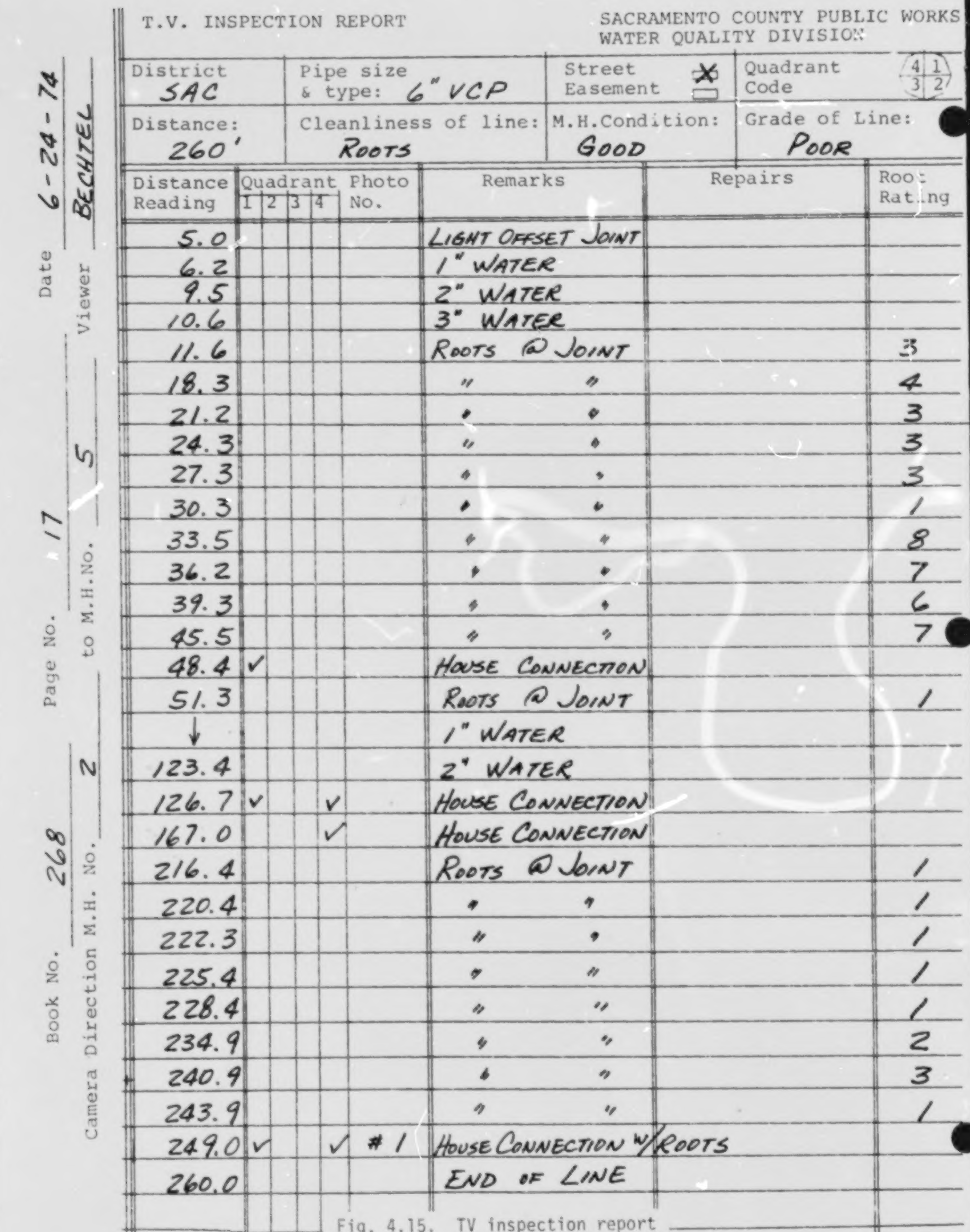
   - OJ Offset joint. Can be followed by a number or fraction to indicate inches or fractions of an inch out of line.

   - GDS Grade defect, starting point.

   - GDE Grade defect, ending point.

   - CUW Camera under water. Point where lens was more than half covered by water.

   - COW Camera out of water. Point where lens was less than half covered by water.



Date 6-24-74

Viewer BECHTEL

Page No. 17

Book No. 268

Camera Direction M.H. No. 2 to M.H. No. 5

T.V. INSPECTION REPORT

SACRAMENTO COUNTY PUBLIC WORKS
WATER QUALITY DIVISION

District SAC	Pipe size & type: 6" VCP	Street ☒ Easement ☐	Quadrant Code 4 1 / 3 2
Distance: 260'	Cleanliness of line: ROOTS	M.H.Condition: GOOD	Grade of Line: POOR

Distance Reading	Quadrant 1	2	3	4	Photo No.	Remarks	Repairs	Root Rating
5.0						LIGHT OFFSET JOINT		
6.2						1" WATER		
9.5						2" WATER		
10.6						3" WATER		
11.6						ROOTS @ JOINT		3
18.3						" "		4
21.2						" "		3
24.3						" "		3
27.3						" "		3
30.3						" "		1
33.5						" "		8
36.2						" "		7
39.3						" "		6
45.5						" "		7
48.4	✓					HOUSE CONNECTION		
51.3						ROOTS @ JOINT		1
↓						1" WATER		
123.4						2" WATER		
126.7	✓			✓		HOUSE CONNECTION		
167.0				✓		HOUSE CONNECTION		
216.4						ROOTS @ JOINT		1
220.4						" "		1
222.3						" "		1
225.4						" "		1
228.4						" "		1
234.9						" "		2
240.9						" "		3
243.9						" "		1
249.0	✓			✓	#1	HOUSE CONNECTION w/ROOTS		
260.0						END OF LINE		

UM 10/73

Fig. 4.15. TV inspection report

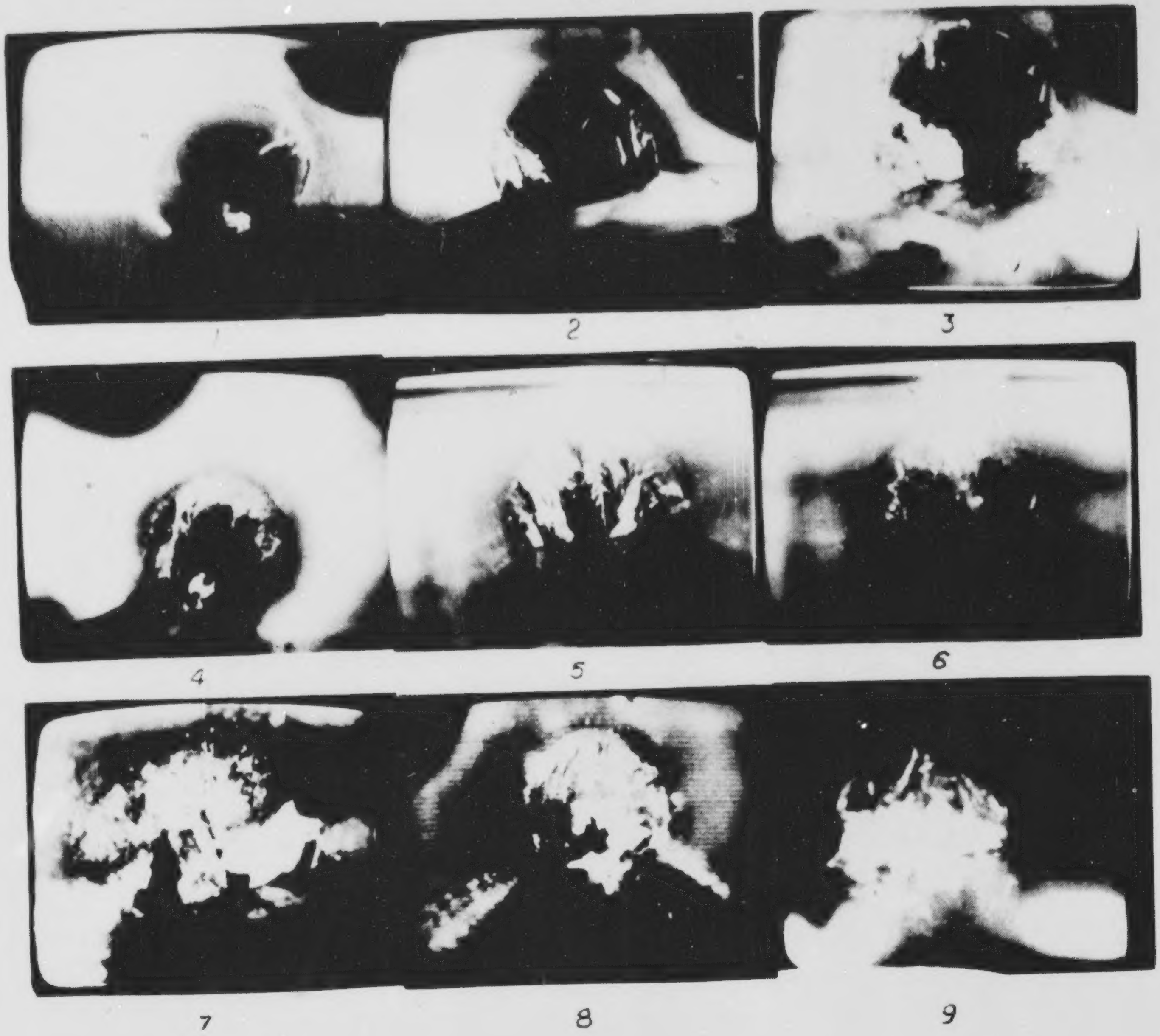


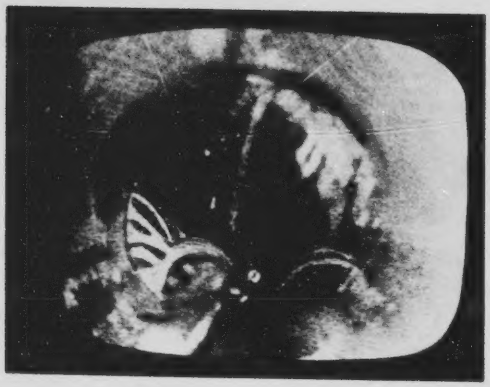
Fig. 4.16. Root rating system
(Courtesy of Sacramento County, Division of Water Quality)

Combinations of these are used to provide information about one location. Example - 263 SC-1-R2-15 = "Station 263, Service Connection from Quadrant One, Roots to rating two, infiltration at approximately five gallons per minute, all from service lateral."

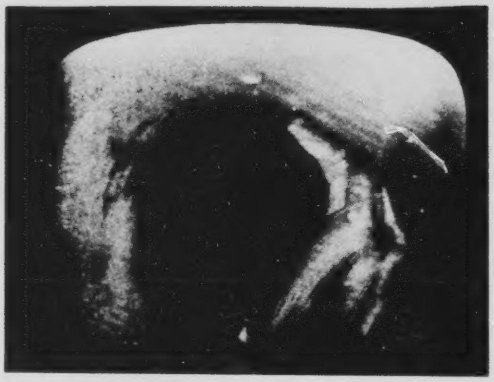
2. Polaroid still photographs, black and white, are often used to support log entries. Infiltration points, bad offsets, damaged laterals, root growths, and broken pipe locations are examples. When each photo is taken, the footage and log entry are recorded on the back of the photo (where a video-footage readout system (Fig. 4.12) is not provided or used). (Figures 4.17 and 4.18).

    a. Polaroid cameras have an automatic exposure device that automatically makes a good picture from the light in the television monitor. There must be a minimum of other light sources that can affect the camera's light adjustment process. In some situations, a special hood may be necessary to eliminate other light sources. This hood must permit the front face of the camera, as well as the electric eye port, to be exposed to the monitor picture.
    b. To be effective for focus, a polaroid camera must have a close-up lens and sighting kit.
    c. Bright lighting behind a polaroid camera can cause reflections in the glass face of the monitor. Adequate curtains or shrouding should be provided to block out background light.

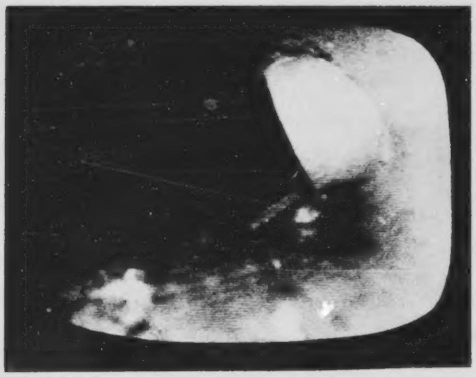
3. Video tape recordings can be used in place of a polaroid camera. Video tapes are able to provide a better record of some types of pipe situations. While most video tape recorders have the ability to record the voice of the TV technician as he describes the sewer, defects observed, and the footage of the situation being viewed, voice records are not required when a video footage readout system is provided and used. Video footage readout systems are helpful, but a TV technician's actual description and comments are very useful when replaying the video tape in an office for someone who is not very familiar with the conditions in the collection system. These systems cannot replace the expertise of an experienced operator who can accurately describe the condition of the pipe on the audio portion of the video tape.



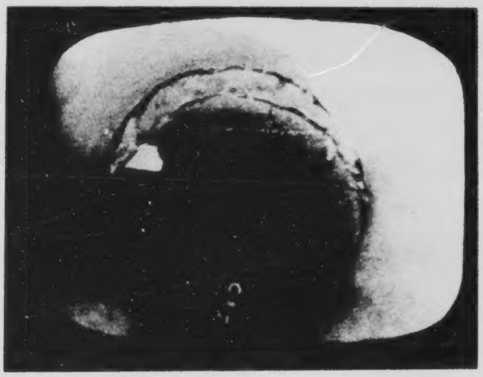
Infiltration at defective pipe joint



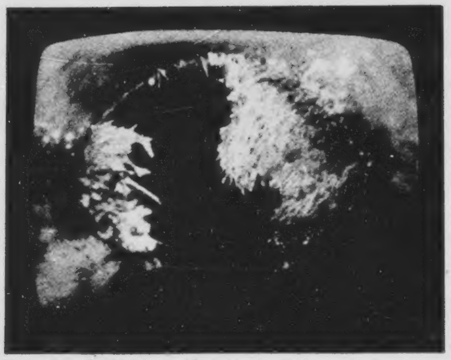
Infiltration or inflow at defective service connection



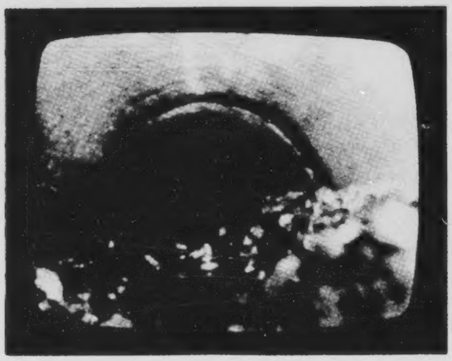
Protruding service tap.



Drop joint.

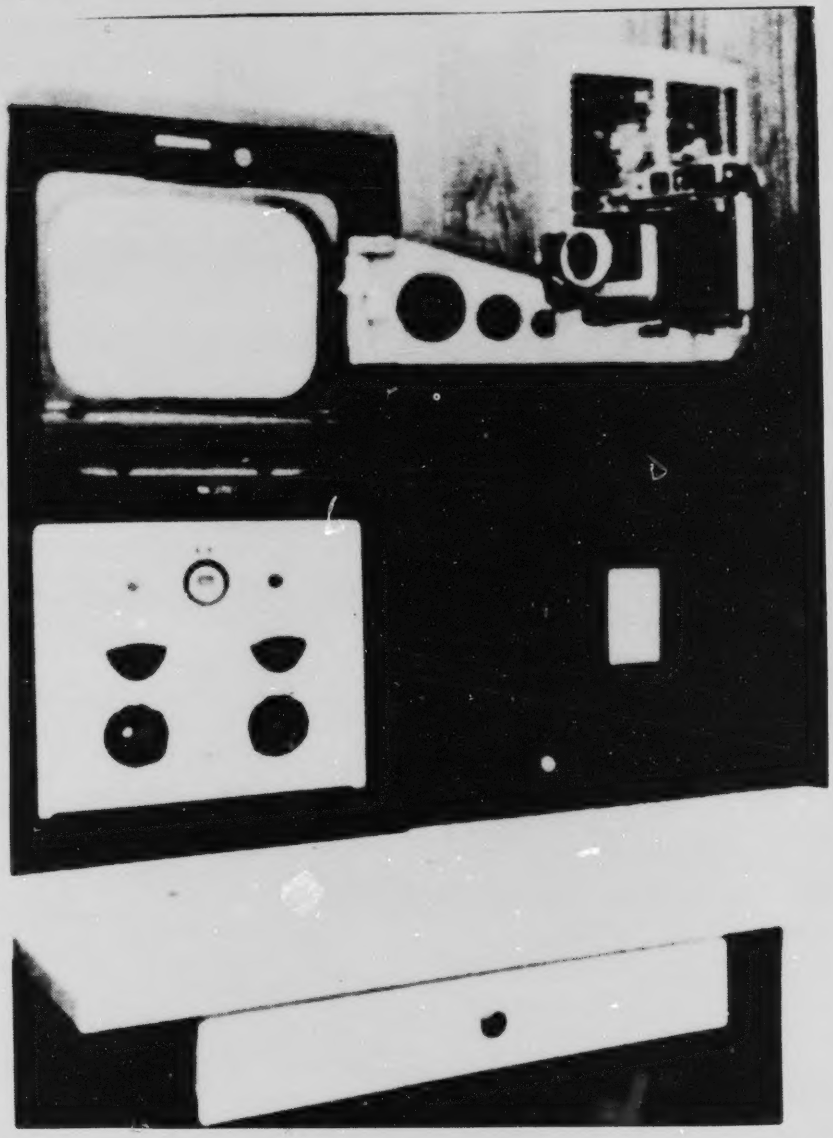


Root intrusion.



Dirty line, gravel and debris.

Fig. 4.17. Typical data available from CCTV sewer inspections



Note swing arm for polaroid camera at proper distance from television monitor. Use of this device requires closed room with all lights out to prevent reflection from monitor glass cover.

Fig. 4.18. CCTV system operator's station

Another feature usually provided with video recording equipment is a selector switch. This three position switch permits televising without recording, televising and recording at the same time, and instant replay of recorded tape after tape rewind. If the operator sees an object or situation to be video taped, the operator starts the recorder, talks into the microphone to describe the situation, footages or other remarks, and then stops the television camera progress after the TV camera has passed the problem area. The operator may then rewind the video tape to the place it was when the recording was started, switch to "VIR" and replay the recording in the monitor to make certain the record and words desired are correct. The operator can then switch back to televise, switch off the recorder and proceed on down the pipe.

Some of the advantages of a video recording system are:

a. The system records motion while still photography freezes motion. In an infiltration situation, the ability to record water flow in action for later viewing has definite advantages.
b. Where a pipe is off-grade, starting the video recording at the beginning of the defective area and keeping it operating during the full passage is desirable. When the supervisor reviews the tape, the supervisor can determine the seriousness of the situation and the necessary corrective action. If a video footage readout system is used, footages are automatically recorded on the tape. When no video footage readout system is provided, the operator should call out footages at frequent and regular intervals into the audio recording system of the tape recorder.

NOTE: IN COLLECTION SYSTEMS WITH DIPS OR SAGS WHERE WATER IS ALLOWED TO STAND, SOLIDS CAN SETTLE OUT AND CREATE A DANGEROUS NUISANCE BY PRODUCING HYDROGEN SULFIDE AS WELL AS BY CAUSING HIGH MAINTENANCE COSTS. VIDEO TAPE DOCUMENTATION OF THE EXTENT AND SEVERITY OF THESE LOCATIONS WILL PROVIDE THE NECESSARY INFORMATION SO ECONOMICAL AND QUICK REPAIR OR CORRECTION OF THE SITUATION CAN BE MADE.

QUESTIONS

4.43I Why should the TV camera be stopped while the operator records data?

4.43J What items are photographed with a polaroid camera?

4.43K What are some of the advantages of using a video tape over a polaroid camera?

4.433 Special Precautions in Televising Collection Systems

Certain types of conditions encountered when televising sewers require special precautions. The operator and the crew should brief each other on the procedures to follow in the event these situations are encountered and there is a risk of damage or wedging of the camera in the sewer.

1. Offset joints restrict the pipe diameter and can cause a camera to wedge tightly in place rather than pass through. Two different types of common offsets require two different procedures.

    a. A horizontal offset is where the joint section is shown to be out of alignment to the right or left. As an operator gains experience in reading the severity of these offsets, the operator will know if the camera assembly can pass these or not. Where there is doubt, the operator will advise the worker at the pull winch, usually with a simple two word announcement, "RIGHT OFFSET", or "LEFT OFFSET". The pull winch worker will then apply only enough pressure on the winch crank handle to move the camera slowly ahead. If you find a sudden resistance to the progress of the camera, YOU MUST NOT ATTEMPT TO INCREASE FULL PULLING POWER ON THE CAMERA ASSEMBLY.

Attempting to force the camera past such an obstruction can cause it to be wedged so tightly that the tag line winch cannot pull the camera back out the sewer. When the pull winch worker finds that moderate pressure on the winch crank cannot move the camera ahead, the worker should announce, "WE ARE HUNG UP". The camera should then be pulled back out of the line with the tag line winch. The bad offset should be repaired before another attempt is made to televise that run of pipe.

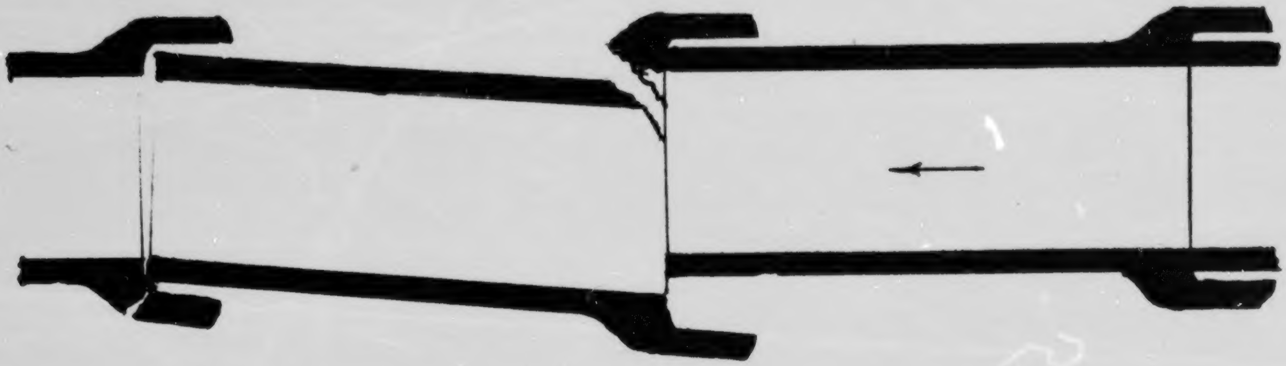
b. Two types of vertical offsets may be encountered and each requires a different procedure. A 'DROP JOINT' is where the camera must drop down to get into the next section of pipe. A 'JUMP JOINT' is where the camera has to be lifted up in order to get into the next section of pipe. (See Figure 4.19).

1) Where the operator sees a drop joint ahead, the pull winch worker is warned. The camera progress is reduced to an extremely slow speed. In most cases, and with a little experience, an operator can determine if the joint can be passed without damage or wedging several inches ahead of the camera. If there is any doubt, the attempt to pass a drop joint should not be made. If the pull winch worker feels the camera come to a sudden stop, the worker should not attempt to pull it farther.

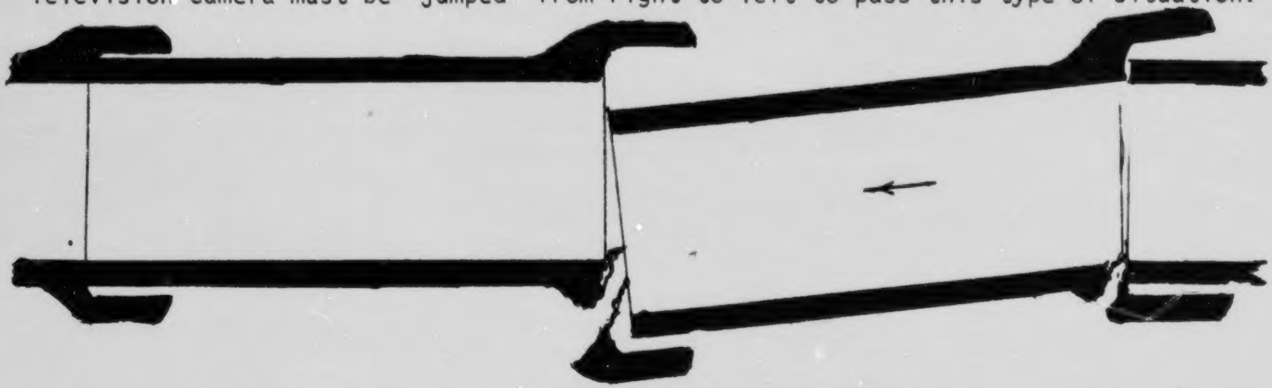
   As with a tight horizontal offset, the camera should be pulled back out of the line and the pipe joint repaired before televising that run again. In addition to possible damage to the camera in passing such a joint, or attempting to, the ability to pull the camera back out may be lost after the joint is passed. Should a point farther down the pipe prevent any more forward progress, the camera will have to be pulled back out with the tag line winch and a drop joint will become a jump joint. If the camera becomes wedged tight in the pipe, excavation to recover the camera will be necessary.

2) Where the operator sees a jump joint ahead, the pull winch worker must be warned. The camera may be moved without danger until the lower skids butt into the ledge and progress comes to a halt. The operator must decide whether to try to 'jump' the camera or

DROP JOINT:
Pulling television camera from right to left past this joint will cause it to 'drop'.



JUMP JOINT:
Television camera must be 'jumped' from right to left to pass this type of situation.



Pulling the camera past situations like these can prevent the camera from being pulled back out if a full obstruction is encountered later down the pipe. It is best to document conditions like these, repair them and then re-televise the line.

Fig. 4.19. Drop joint and jump joint

pull it back out. The extent or severity of the offset is the factor to be evaluated. To 'jump' the camera assembly, the pull winch worker takes a fairly heavy tug or pull on the winch cable and holds it. The tag line winch or TV cable is then given a short pull back and released. In effect, the camera and skid assembly are more or less given a heavy jerk. The objective is to pull the lower skids out of contact with the ledge just far enough to allow the pull cable to 'lift them' over the ledge. This procedure may have to be tried several times.

In general, any jump joint that can be negotiated in the above manner can be pulled back through without problem in the event the camera has to be backed out of the line.

2 When the camera goes under water to a point where the top half of the pipe cannot be clearly seen, the operator is no longer able to see obstructions or offset joints adequately to prevent wedging or damage. The operator should advise the pull winch worker of the circumstances by announcing "CAMERA UNDER WATER, TAKE IT SLOW AND EASY". If the pull winch worker finds the camera has stopped and cannot be moved with very moderate pressure on the winch handle, the worker should advise the operator. To be safe, back the camera out of the sewer and have the sewer repaired at that point before trying to pull the camera through.

If the submerged section of the sewer must be inspected, plug the sewer at the upstream manhole. If this does not lower the water level in the sewer enough, a high velocity cleaner may be helpful. Have the TV camera follow the high velocity cleaner through the sewer. The jet of water from the nozzle will push the water clear of the pipe for a short distance. When the TV picture becomes submerged again, stop the high velocity cleaner and allow the water to flow out the pipe. Start the high velocity cleaner again and repeat until the submerged section has been inspected.

3. When coming out of a situation where the camera has been under water, it is possible for the viewport to become fouled with grease or other surface debris. In most cases the decrease in visibility will be negligible, but it is possible to have a foggy or indistinct picture which can reduce the visual inspection effectiveness. There are several things that can be attempted to clear the viewport.

    a. If the distance to the downstream manhole is more than fifty or a hundred feet, back the camera up until it is fully under water again. Allow the camera to stand for perhaps a minute to allow any debris on the viewport to be floated off, then pull it forward rapidly to the point where the viewport is once again out of the water. The idea behind this is to create a wave ahead of the viewport that washes surface debris aside with water brought up with the camera. This may be attempted safely several times. Do not pull the camera forward farther than its former progress.

    b. If the distance to the downstream manhole is still over fifty or a hundred feet, open a fire hydrant or similar source of a large volume of water and discharge into the upstream manhole (any upstream manhole) in an attempt to wash the surface debris through the line. Pull the camera back into the water to rinse the viewport and proceed once it is clear.

    c. If the downstream manhole is not too far, pull the camera down to it in the same manner as if it were underwater. This means the pull winch worker moves it slowly, advising of any sudden stoppage of progress. Once at the downstream manhole, clean the viewport and pull it back to the place where it came out of the water and proceed to televise the rest of the pipe.

4. Other obstructions are handled in much the same manner. Such problems as protruding service connections (protruding taps), objects sticking into a pipe, pieces of broken pipe protruding into the pipe, and heavy root developments are typical examples. Once again, teamwork between the crew members will determine if these can be passed without damage to the equipment or if they must be removed before televising the remainder of the line. A rule of common sense is applicable at this point.

A RULE OF COMMON SENSE

RULE: IF A SITUATION IN A PIPE PRESENTS A RISK TO THE CAMERA AND THE TELEVISING EQUIPMENT, IT IS OBVIOUSLY A SITUATION WHICH REQUIRES EXCAVATION AND REPAIR. UP TO THAT POINT, THE CAMERA HAS DONE ITS JOB AND IT CAN BE PULLED BACK OUT AND USED IN OTHER LOCATIONS WHILE THE NECESSARY REPAIRS ARE BEING MADE TO THE PIPELINE. TO RISK DAMAGE AND THE NEED TO REPAIR THE CAMERA CAN PRODUCE UNNECESSARY COSTS. THIS RISK ALSO CAN PREVENT THE USE OF THE TELEVISION EQUIPMENT WHILE CAMERA REPAIRS ARE BEING MADE.

5. Camera tumbled or off-vertical conditions should not be a problem. A properly designed camera and skid assembly should right itself in a straight pipe run. Even if a camera is inverted and the picture is up-side-down, moving the camera back and forth should cause it to return to the upright position.

   a. Bends and some types of offset joints in a pipe can cause a camera to get tilted. This is usually a temporary condition.

   b. If a camera does not right itself in a few feet, it is an indication that something is wrong. A cable could be tangled in the skid assembly, or a root clump has fouled the assembly. Under such circumstances, the operator should select the most rapid and safest method of getting the camera out of the line and determine the cause of the problem.

6. A foggy or indistinct picture, after getting a sharp picture in a pipe, indicates that the viewport and possibly the optical lens of the camera have become fogged. This can take place shortly after a camera has started down the pipe, or it can occur after a camera has pulled past a service with hot or very warm water dumping out of it.

   a. A cold piece of glass placed in a warm and humid atmosphere will fog up. Use of some types of anti-fog compounds may be effective, but the best solution is to warm the camera before placing it in the pipe. A glass surface that is warmer than the atmosphere it is placed in will not become foggy.

   b. When fogging occurs shortly after the camera enters the pipe, it is best to take the camera back out and put it where it can be warmed up to as much as 100°F (38°C). Avoid placing the camera in front of a heater where one side can be warmed more rapidly than the other. Possible ways of warming a camera are to put it in a warm room, or behind or under a cardboard cover in the sunlight, or in a vehicle parked in the sun with the windows closed.

   c. When fogging takes place in a pipe after passing a service with hot water flowing out, simply stop the camera and wait for a few minutes. The warmth will be picked up by the glass parts and de-fogging will take place.

   d. Steam resulting from water striking the hot light assembly can be ignored. It will not last long and provides no serious problem to the picture.

7. Do not allow grease to accumulate on the light head. If the heat from the light ignites the grease, the light head could be damaged beyond repair. Also the fumes and stench from the burning grease that comes out the manhole has a horrible odor.

8. If a sewer is flowing so full that the TV camera will be submerged, plug the sewer at the entrance to the upper manhole and televise the line as soon as the water drops. Be careful that the wastewater held behind the plug does not back up into someone's home or flow out the top of a manhole.

QUESTIONS

4.43L List the types of conditions that the TV camera may encounter which require special precautions.

4.43M Why should you NEVER attempt to force a TV camera past an obstruction?

4.43N If a TV camera encounters a bad joint that it cannot pass, how can the remainder of the line be televised?

4.43O When coming out of a situation where the camera has been under water and the viewport is fouled with grease or other surface debris, what would you do?

4.43P What would you do if you were operating the TV monitor and observed a foggy or indistinct picture shortly after the TV camera entered the pipe?

4.434 Shutting Down After Completion of the Pipe Run

When the operator is able to see the end of the pipe or the hardware in the downstream manhole, the operator should immediately advise the pull winch worker of the situation. If the pull winch worker is able to look into the manhole and see the light of the camera shining on the pipe or hardware, the worker should report this fact to the operator. For all practical purposes, the run has been televised and shut-down procedures should start.

The first act of the shut-down procedure is to turn off all power to the camera and light. Power must be off before anyone attempts to handle the camera or pull it out of the pipe.

The standard light used on a sewer inspection television camera is a quartz-iodine type. These lamps, similar to a projection lamp, achieve extremely high temperatures (in some cases as high as 1,600°F or 870°C). The lamp and its reflector must be permitted to cool to a safe level before anyone handles the camera.

CAUTION: MOST CAMERAS AND MONITORS CONTAIN COMPONENTS THAT CAN BE DAMAGED BY FREQUENT OR SUSTAINED LOW POWER CONDITIONS. AVOID SIMPLY SHUTTING DOWN THE POWER GENERATOR AND ALLOWING THE ENGINE TO COAST TO A STOP WHILE POWER SWITCHES TO THE EQUIPMENT ARE STILL IN THE "ON" POSITION. SHUT OFF, LOCK OUT, AND TAG SWITCHES BEFORE SHUTTING DOWN THE GENERATOR.

4.435 Final Check of Television Survey and Footage Test

Before removing TV equipment from the manhole and turning in the television log sheet (Figure 4.20), every entry should be checked for readability, accuracy, and cleanliness. Poorly written entries or errors in the coded entries can cause costly losses. Dirty logs can make some of the notes and numbers unreadable.

1. Some types of footage meters can develop large errors during a television operation. In most instances this is due to slippages in the measuring device, or frequent backing and forwarding of the camera. To determine if such an error has taken place, compare footage meter distance with distance between manholes shown on wastewater collection system map. If a difference of more than one percent exists,[5] use a tape and measure the distance between the manholes. Also be aware of the fact that maps may contain distance errors.

    a. If a difference of more than one percent in the total distance measured and the footage recorded on the log is evident, add an error factor to the log. This error factor will be the amount of the difference.

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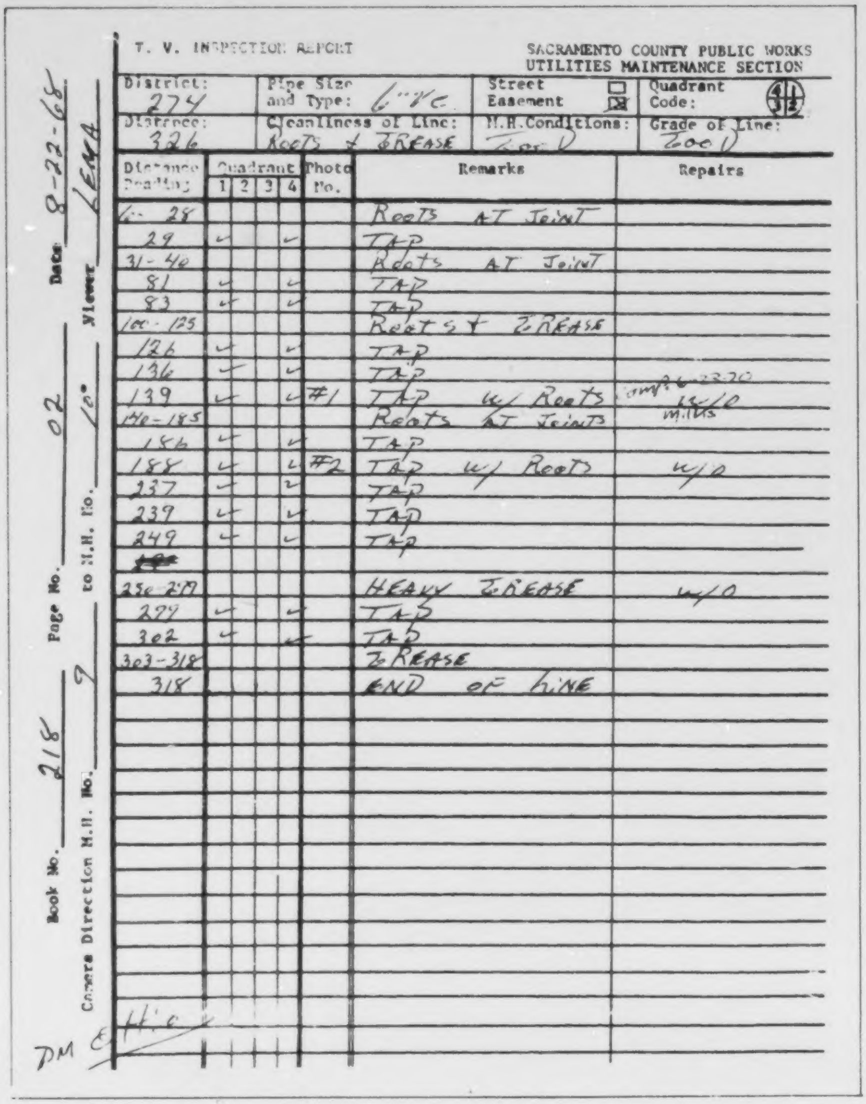
[5] See Appendix M, Applications of Arithmetic to Collection Systems, Section M.9, Solutions to Problems, D. Slope and Grade, for an example of how to calculate the percent error in the footage meter.



T. V. INSPECTION REPORT

SACRAMENTO COUNTY PUBLIC WORKS
UTILITIES MAINTENANCE SECTION

Book No. 218 Page No. 02 Date 8-22-68

Camera Direction M.H. No. 7 to M.H. No. 10 Viewer LEMA

District: 274	Pipe Size and Type: 6" VC	Street ☐ Easement ☒	Quadrant Code: 4 1 / 3 2
Distance: 326	Cleanliness of Line: Roots & Grease	M.H. Conditions: Good	Grade of Line: Good

Distance Reading	Quadrant 1	2	3	4	Photo No.	Remarks	Repairs
0 - 28						Roots at Joint	
29	✓			✓		Tap	
31 - 40						Roots at Joint	
81	✓			✓		Tap	
83	✓			✓		Tap	
100 - 125						Roots & Grease	
126	✓			✓		Tap	
136	✓			✓		Tap	
139	✓			✓	#1	Tap w/ Roots	comp. 6-22-70 w/o
140 - 185						Roots at Joints	Millis
186	✓			✓		Tap	
188	✓			✓	#2	Tap w/ Roots	w/o
237	✓			✓		Tap	
239	✓			✓		Tap	
249	✓			✓		Tap	
~~[illegible]~~							
250 - 277						Heavy Grease	w/o
277	✓			✓		Tap	
302	✓			✓		Tap	
303 - 318						Grease	
318						End of Line	

DM

Fig. 4.20. Completed CCTV inspection report

(Note 318 as end of line for last entry and line distance as 326)

b. Give the error factor a sign which shows how the television log should be corrected. If the difference between the tape measured distance and the television footage figure shows the tape distance was shorter than the footage reading, the error factor is negative, or subtracted from the TV log figures. If the other situation is evident, the taped distance is longer than the footage of the TV log, the factor is added.

c. Establishment of the error factor is important when it becomes necessary to excavate some point for repairs to the sewer. The correct distance permits a person to determine that some defect observed by the camera has to be a certain distance from the upstream manhole. If the error factor were not available, a person might dig at the logged footage, find that there was an error and then not know which direction and how far exploratory excavation should be made.

4.436 Removal of TV Equipment from Manholes and Preparation for Next TV Run

After the inspection report (Fig. 4.20) has been checked and found satisfactory, the TV equipment is removed from the manholes and made ready to be moved to the next section to be televised.

1. The pull winch worker winches the camera forward until the tow bridle is observed coming into the manhole. The tasks listed below are performed in sequence.

   a. Remove the fair lead hardware from the manhole.

   b. Move the pull winch stand from over the manhole to permit access into the manhole.
   NOTE: If possible, remove the camera without entering the manhole by using the pull cable.

   c. Observe manhole safety precautions (see Section 4.1, TRAFFIC AND MANHOLE SAFETY).

   d. Enter the manhole and first pull the camera forward by grasping the tow bridle.

e. When the front of the camera has been pulled part way into the manhole, finger-tip check the temperature of the light assembly, NEVER TOUCHING THE LAMP ITSELF. If it is still quite hot, wait for it to cool to a point that it can be safely handled.

f. As soon as the lamp assembly is cool, the viewport cover is installed on the camera. This cover protects the camera vidicon tube from the possibility of being pointed towards the sun while being removed from the manhole.

g. After the cover is installed, the tow cable is unhooked from the bridle and the camera pulled the rest of the way into the manhole.

h. The tag line winch cable is next disconnected from the tag line bridle on some types of equipment. The pull winch worker tosses the hardware from this winch cable back into the pipe where it will not have a chance to tangle with the power cable strain relief and hook-up hardware. When this task is complete, the order is given "RETRIEVE THE TAG LINE". The tag line winch is then used to rewind the winch cable.

i. The next step is to disconnect the power cables. Install the special plug or cap to prevent debris and moisture from getting to the electrical contacts at the end of the power cables. These plugs or caps are installed by the pull winch workers before the next step is taken.

j. When the tag line winch cable has been pulled in adequately to prevent the ends of it and the power cable from getting tangled, the cable strain relief of the power cable is unhooked from the tag line bridle. The order can then be given to "RETRIEVE THE POWER CABLE".

k. The camera assembly then may be removed from the manhole and the job is complete at the downstream manhole.

2. While rewinding the tag line and the power cable, the equipment is cleaned. This consists of wiping the cables free of any bits of paper or other debris as they are returned to the winch drum or cable reel (if used).

   a. Wiping is best done with a piece of foam rubber or a felt pad. Use of a cloth with threads can cause pieces of the cloth to be torn free and to wind around the cables.

WARNING

NEVER ALLOW A WINCH CABLE TO BE PULLED RAPIDLY BETWEEN THE BARE FINGERS OR BARE HAND. EVEN A LEATHER GLOVE IS NOT SAFE FOR THIS ACTIVITY. SMALL SINGLE STRANDS OF THE CABLE CAN BREAK AND STICK OUT WITH THE ABILITY TO RIP BARE SKIN. A SCRATCH FROM A CABLE THAT HAS BEEN IN A SEWER ALMOST **PROMISES SERIOUS INFECTION.**

   b. While wiping the returning cables, they are fed onto the drum or reel to effect level winding and avoidance of balling up at one point. A winch or cable reel permitted to ball up is able to become tangled and present problems when used on the next job.

3. If the camera and skid assembly are fouled with debris, they should be cleaned before storing or starting another run. Large clumps of debris are usually removed with a stick used as a scraper. A water jet from a garden hose is used to finish the job. Wipe the viewport dry as a final job.

a. Where petroleum base residues are encountered and cause a camera and skid assembly to become coated, paint thinner or an approved solvent may be used to clean a camera. Do not use gasoline. Extreme fire hazard can result with the use of gasoline and gasoline can be harmful to seals on the camera. The camera should be thoroughly rinsed with water after cleaning. Keep cleaning chemicals away from the seals. Apply cleaning clemicals with a cloth and wipe away the chemicals immediately after cleaning.

Whenever petroleum base residues are observed in a sewer, their location should be recorded and forwarded to your supervisor. The supervisor can determine the source of the discharge and decide if it is illegal.

b. Use of carbon tetrachloride or chlorthane chemicals for cleaning a camera or other parts should be avoided. Many of the polyesters used in seals and coatings of a camera and a cable are destroyed by these chemicals. Carbon tetrachloride also is hazardous to your health.

QUESTIONS

4.43Q What must be done before turning in the television log sheet?

4.43R Why should the distance measured by the footage meter be verified?

4.43S What is the first step of the shut-down procedure when the TV run has been completed?

4.43T What check should be performed on the light assembly before the viewport cover is installed on the camera and the camera removed from the manhole?

4.43U When the power cables are retrieved back up the sewer line, how are the electrical contacts at the end of the power cables protected from debris and moisture?

4.43V How would you clean the tag line and power cable while they are being rewound?

4.44 Purchase of Closed Circuit TV Equipment

When your agency decides to purchase closed circuit TV equipment, the selection of a vendor, the type of equipment, accessories needed, and total overall operational cost are serious considerations. Perhaps the best place to start is to talk to other collection system workers and consider their experiences and recommendations to help make your decisions. Keep in mind that your particular needs are of primary importance. A piece of equipment must meet your needs and not someone else's needs. Equipment manufacturers' shows at national meetings such as the annual Water Pollution Control Federation Conferences provide an excellent opportunity to inspect the equipment of many manufacturers and also to discuss your needs with the manufacturers' representatives. If possible, arrange for a demonstration of the equipment you are considering purchasing so you and your crews can become familiar with the actual operation and performance of the equipment. See appendix at end of this chapter (Section 4.9) for details on desirable features of equipment.

QUESTIONS

4.44A How would you select the best closed circuit TV equipment for your agency?

4.45 Photographing the Television Monitor Picture

Permanent still photographic records of conditions in a wastewater collection system are frequently made by photographing the video picture in the television monitor. Any of several types of cameras may be used to take photographs; however, it is important to understand some details of photographic work in order to consistently get good results.

1. Only high-speed film should be used. While slower film can take photographs, the capacity to stop the action of water motion in a pipeline is lost and can result in blurred parts of the photo.

2. The television monitor is a weak source of light, especially where large parts of the video picture are dark. Because of lighting problems the camera must be held as close to the monitor as possible. This will require the use of a close-up lens on most cameras and the use of the smallest f-stop possible (resulting in the largest possible iris opening with the fastest possible shutter speed).

3. Time exposures of a television monitor are not recommended because the results are difficult to understand.

4. The most popular camera used for taking still photographs of the inside of a pipe shown on a television monitor is the polaroid. In addition to having a convenient and uncomplicated close-up kit available, it utilizes the fastest film available on the market in black and white (3,000 ASA).

Polaroid also is able to provide the resulting photograph in a matter of 15 seconds and assures that the scene desired is acceptable.

a. Because polaroid cameras have an automatic control for shutter speed and iris opening that is sensitive to the light entering the window of an electric eye on the camera front, only the light from the TV monitor should be permitted to fall on the camera front. This often requires the use of a hood to eliminate all other light between the camera and the monitor.

b. Where a hood is not used, all background light in the monitor viewing room should be eliminated when using a polaroid. The glass front of the monitor tube is highly reflective and any background light will be reflected back into the photographic camera, resulting in both faulty camera shutter adjustment and poor picture quality.

c. Black and white polaroid film is so fast that it is possible for the camera to stop the sequencing action of the television system. The average sewer inspection television system erases and builds a new picture 60 times per second. Between each picture the monitor may be dark or practically dark when the exceptionally high speed shutter of the polaroid camera records a picture. When this happens, the operator can only try again with the camera. A dark or blurred picture does not necessarily indicate any defect of the equipment or procedure.

d. Polaroid black and white photographs require a coating for permanency. This is usually provided by a saturated wick in a small capsule container furnished with each package of film. Allow the photograph to dry after peeling from its emulsion package, then coat the face of it with the wick. Photographs should not be handled until the coating is completely dry.

e. Where video tape readout is not provided, all still photographs should be marked with the date and information regarding the line and footage location of the scene in the picture. In cases where a written television log is being kept, the photograph should be logged and the log entry number marked on the photograph. Most of these entries are made on the backs of the photographs after they are fully dry and can be handled without damage. The usual procedure is to clip or staple photographs to the written log sheet after each television run.

4.46 Use of 3D Photography

Another method of inspecting sewers is by the use of 3D photography. To use this technique, a camera is placed on skids and pulled through the sewer. As the camera travels through the sewer, a photograph is taken every three or four feet. A special viewer is used to produce a three-dimensional photo of the sewer. This procedure is much cheaper than using closed circuit television. A disadvantage is that if you need more photos or details, you don't find out until a couple of days later after the film has been developed and studied.

QUESTIONS

4.45A How can photographs be made of a problem inside a pipe?

4.45B What kind of film should be used to take photos of the video picture in the TV monitor?

4.45C What kind of camera is most commonly used to take photos of the video picture in the TV monitor?

4.45D What information should be attached to a photograph taken of the inside of a pipe?

END OF LESSON 3 OF 5 LESSONS

ON

SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 3 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

12. What information can be obtained from a closed circuit television inspection of a sewer?

13. What must a collection system crew do before starting to set up the TV inspection equipment?

14 How is the TV inspection camera moved through a sewer?

15. How does a TV inspection crew communicate with each other?

16. What conditions require that special precautions must be taken when inspecting sewers with a TV camera?

17. How is a TV camera removed from the sewer after an inspection run is completed?

18. Why must the distance recorded by a footage meter be compared with the actual measured distance?

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 4 of 5 Lessons)

4.5 SMOKE TESTING

4.51 Purpose

Use of smoke for testing sewers is best done when the ground water is low so any cracks will leak smoke. Realize that the location of smoke on the ground surface does not necessarily reveal where the smoke is escaping underground, but only the path of travel to the ground surface. Smoke testing of wastewater collection systems (Fig. 4.21) is used to determine:

1. The sources of entry to the collection system of surface waters, also called surface inflow. This includes rain or storm waters, street or surface wash waters, and in some cases, irrigation waters.
2. Positive proof that buildings or residences are connected to a wastewater collection system.
3. Location of certain types of illegal connections to a wastewater collection system. Included with these connections are such things as roof leaders or downspouts, yard drains, industrial drains, and some types of cooling tower water drains.
4. Location of broken sewers due to settling of foundations, manholes and other structures.
5. Location of "lost" manholes and diversion points.

4.52 Equipment

All of the following equipment are used or are applicable to a smoke testing operation:

1. Smoke blower unit (Figure 4.22). This is usually a squirrel cage blower with a gasoline engine and belt drive. The average

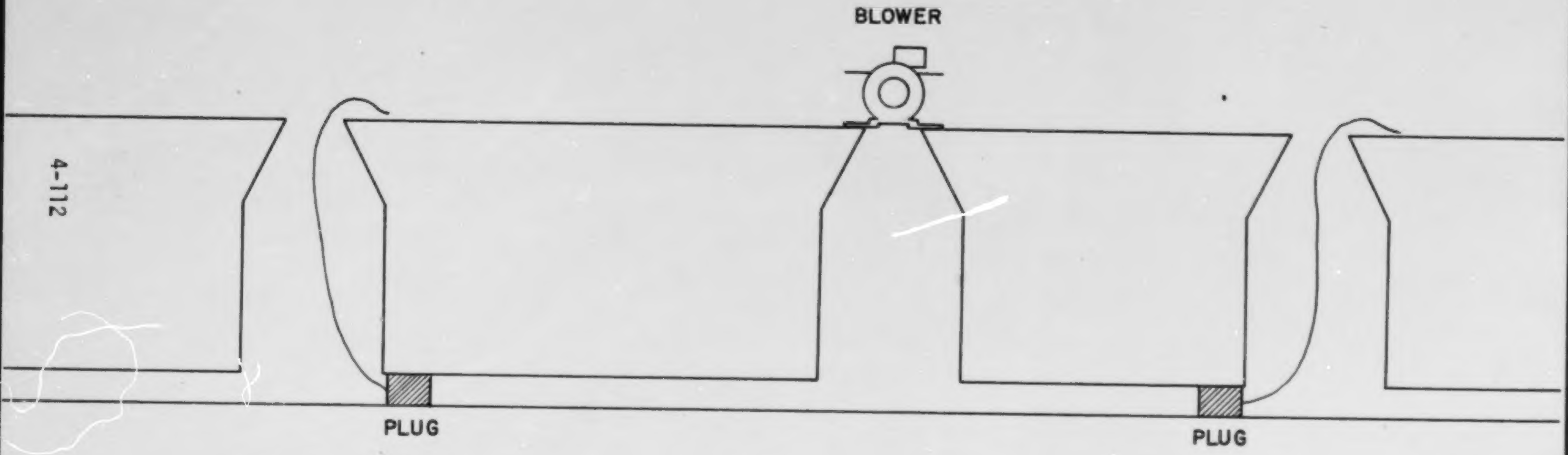

BLOWER
PLUG
PLUG

Fig. 4.21. Smoke testing

blower capacity will be over 1,700 CFM and under 3,000 CFM. The blower will have a base with a rubber gasket underneath the base that permits it to set over and force a blast of air into an open manhole.

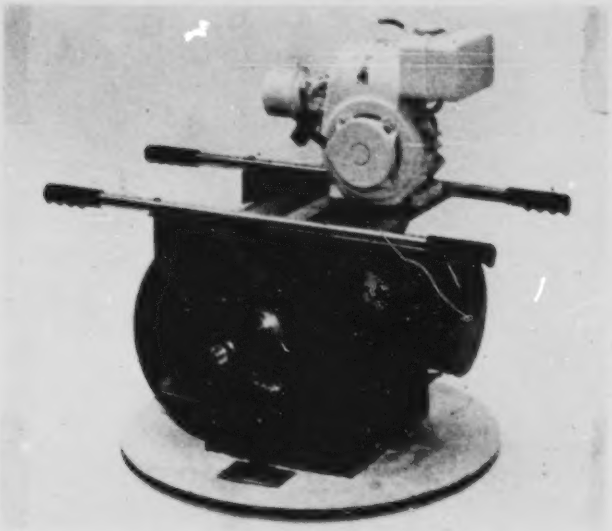


Fig. 4.22. Manhole smoke blower. Fiberglass base fits over opening of manhole and small port for suspending smoke bomb on wire or chain.
(Courtesy of Superior Signal Company, Inc.)

2. Pipe plugs (Figure 2.23) to isolate two sections of pipe between three adjacent manholes. These may be mechanical or inflatable.

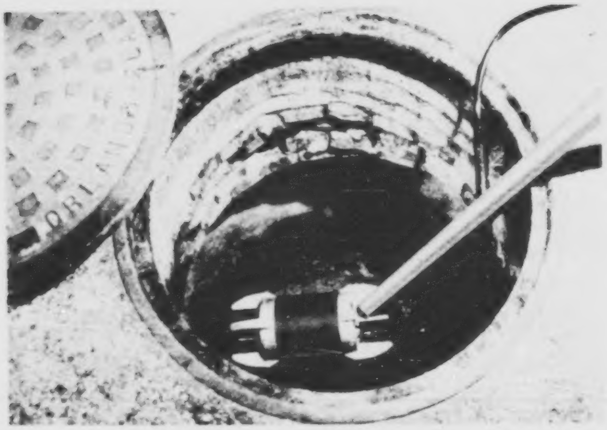


Fig. 4.23. Pipe plug. An inflatable pipe plug that can be installed and removed without having to enter a manhole. This provides maximum safety and speed for smoke testing work by eliminating the need to enter the manhole.

Where there are high wastewater flows that prevent safe plugging of a line to be smoke tested, heavy canvas or curtains with weights or sand-bags on the bottom may be used to confine the smoke to the section being tested (Section 4.54).

3. Smoke bombs (Figure 4.24) of the three minute or five-minute duration type.

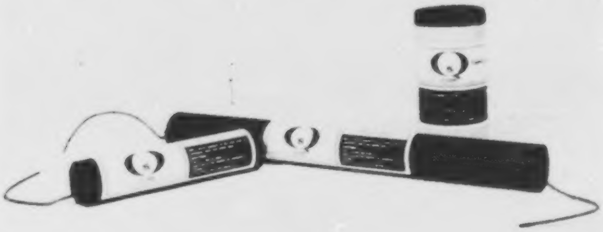


Fig. 4.24. Smoke bombs

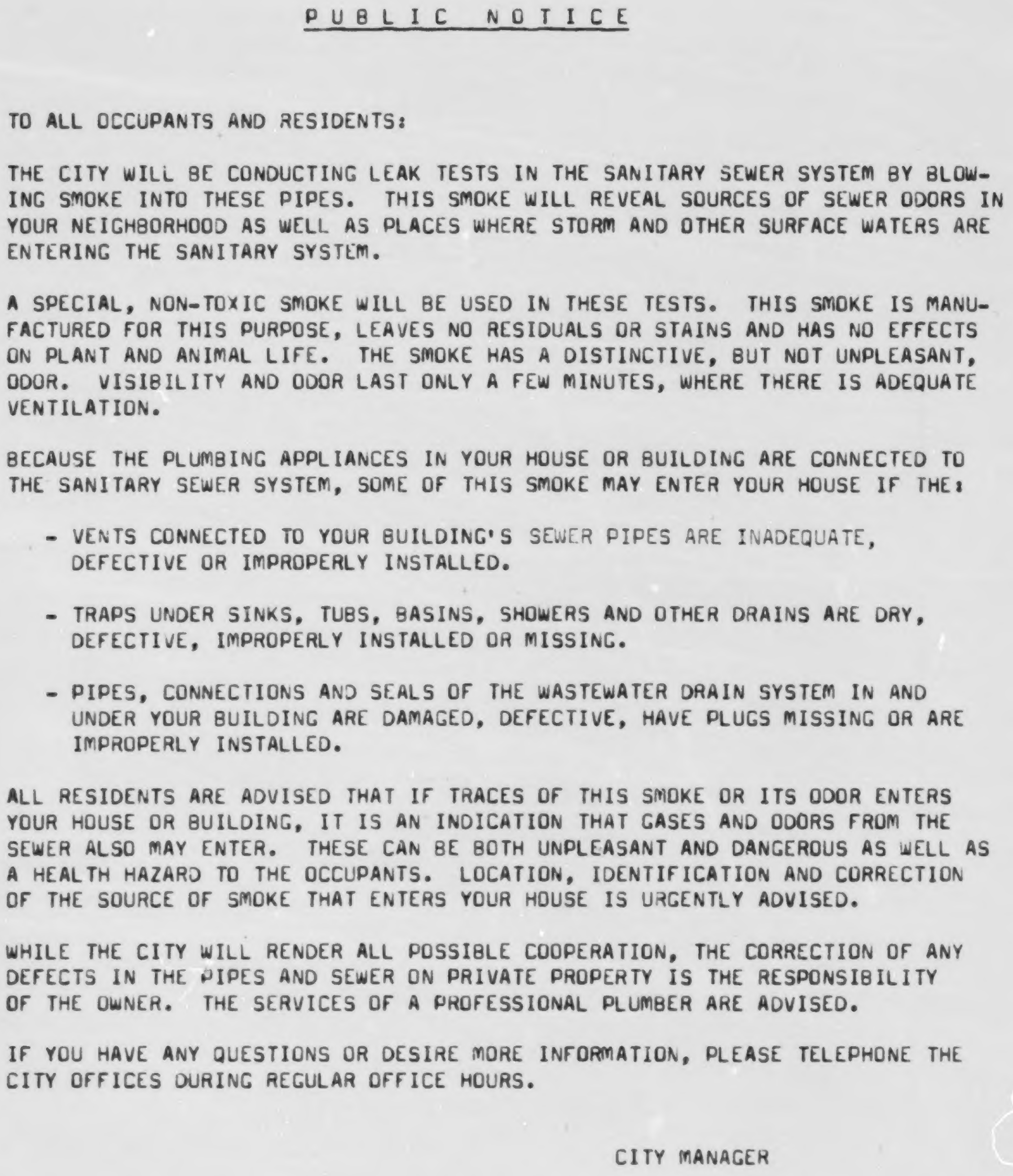
WARNING: USE ONLY MAILABLE SMOKE BOMBS SPECIFIED TO BE SAFE AND TO HAVE NO TOXIC OR RESIDUAL EFFECTS. NEVER USE MILITARY TYPES OF COLORED OR SIGNAL SMOKE BOMBS FOR THIS APPLICATION DUE TO EXPLOSIVE DANGER AS WELL AS DANGER FROM CONTACT TO WORKERS AND PROPERTY.

4.53 Preparations

Smoke testing of wastewater collection systems has a chance to affect the occupants of buildings connected to the line being tested. Such factors as defects in the sewer system of the buildings, dry traps, defective wax ring under commodes, vents terminated in an attic, or clean out plugs missing from sewers can cause smoke to enter the building. Adequate preparation plus good advance public relations is a necessity in order to avoid panic or severe alarm among persons having the smoke enter a building or a home.

1. Warn the public in advance when and where smoke testing is planned. A typical public announcement is shown in Figure 4.25. This type of announcement should be published in a local paper and be prominently displayed and distributed in the area to be smoke tested. Occupants should be requested to run some water into sewers that are not used regularly before the test starts to fill traps that may have dried out.

2. The local fire and police departments must be thoroughly briefed on the smoke testing operation and its safety. In addition, the fire department should be advised of the area to be smoke tested at the start of each day of testing. If possible, it is a good idea to have a vehicle from the fire department with one or two members of that department accompanying the smoke testing operation.



PUBLIC NOTICE

TO ALL OCCUPANTS AND RESIDENTS:

THE CITY WILL BE CONDUCTING LEAK TESTS IN THE SANITARY SEWER SYSTEM BY BLOWING SMOKE INTO THESE PIPES. THIS SMOKE WILL REVEAL SOURCES OF SEWER ODORS IN YOUR NEIGHBORHOOD AS WELL AS PLACES WHERE STORM AND OTHER SURFACE WATERS ARE ENTERING THE SANITARY SYSTEM.

A SPECIAL, NON-TOXIC SMOKE WILL BE USED IN THESE TESTS. THIS SMOKE IS MANUFACTURED FOR THIS PURPOSE, LEAVES NO RESIDUALS OR STAINS AND HAS NO EFFECTS ON PLANT AND ANIMAL LIFE. THE SMOKE HAS A DISTINCTIVE, BUT NOT UNPLEASANT, ODOR. VISIBILITY AND ODOR LAST ONLY A FEW MINUTES, WHERE THERE IS ADEQUATE VENTILATION.

BECAUSE THE PLUMBING APPLIANCES IN YOUR HOUSE OR BUILDING ARE CONNECTED TO THE SANITARY SEWER SYSTEM, SOME OF THIS SMOKE MAY ENTER YOUR HOUSE IF THE:

- VENTS CONNECTED TO YOUR BUILDING'S SEWER PIPES ARE INADEQUATE, DEFECTIVE OR IMPROPERLY INSTALLED.
- TRAPS UNDER SINKS, TUBS, BASINS, SHOWERS AND OTHER DRAINS ARE DRY, DEFECTIVE, IMPROPERLY INSTALLED OR MISSING.
- PIPES, CONNECTIONS AND SEALS OF THE WASTEWATER DRAIN SYSTEM IN AND UNDER YOUR BUILDING ARE DAMAGED, DEFECTIVE, HAVE PLUGS MISSING OR ARE IMPROPERLY INSTALLED.

ALL RESIDENTS ARE ADVISED THAT IF TRACES OF THIS SMOKE OR ITS ODOR ENTERS YOUR HOUSE OR BUILDING, IT IS AN INDICATION THAT GASES AND ODORS FROM THE SEWER ALSO MAY ENTER. THESE CAN BE BOTH UNPLEASANT AND DANGEROUS AS WELL AS A HEALTH HAZARD TO THE OCCUPANTS. LOCATION, IDENTIFICATION AND CORRECTION OF THE SOURCE OF SMOKE THAT ENTERS YOUR HOUSE IS URGENTLY ADVISED.

WHILE THE CITY WILL RENDER ALL POSSIBLE COOPERATION, THE CORRECTION OF ANY DEFECTS IN THE PIPES AND SEWER ON PRIVATE PROPERTY IS THE RESPONSIBILITY OF THE OWNER. THE SERVICES OF A PROFESSIONAL PLUMBER ARE ADVISED.

IF YOU HAVE ANY QUESTIONS OR DESIRE MORE INFORMATION, PLEASE TELEPHONE THE CITY OFFICES DURING REGULAR OFFICE HOURS.

CITY MANAGER

Fig. 4.25. Typical public announcement

3. All workers who will participate in the smoke testing should be fully trained and daily briefed in the proper method of handling persons who discover smoke in their homes or smoke coming up all over their yard and around their house. Anticipate that such a circumstance will occur and that it can have a potential for generating considerable concern among certain types of individuals.

   a. Workers on the team should be drilled in the concept that any smoke entering a building or residence reveals that gases from the sewer can and do enter the building. Prompt correction of the problems by the owner is neccessary for the health and safety of the building's occupants.

   b. Where smoke is coming from a drain in a plumbing fixture, first inspect the trap water seal to determine if the trap is dried out or is defective. Where a trap is dried out and unlikely to be used, suggest that the traps be filled with mineral oil. Do not put mineral oil into a trap that will be used occasionally.

   c. A missing wax ring under a commode is easy to identify and to tell a householder how to solve. In any event, a plumber can replace a wax ring.

4. There are conditions where an observer and recorder may enter private property, therefore adequate consideration of, and good public relations with owners and occupants must be exercised.

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In a city that had a rash of Peeping Tom reports, girls were employed as observers and reporters during smoke testing activities. While an irate and disturbed citizen might accuse a male city employee of compromising the privacy of her bedroom window, it is unlikely that she would throw the same charge at a female. Advance publicity, identificable clothing for workers, signs on equipment, and good public relations all help to avoid upsetting the public.

5. A city or agency attorney should be advised of the smoke testing methods and some of the possible adverse results. Although there is no basis for damage or tort (civil) claims from a building owner for smoke disturbance or alleged damage to interiors, such claims may require defense by an attorney. Discuss with the attorney what kind of information and reports are needed if any incidents or difficulties arise during smoke testing.

6. Crew that does smoke testing should inspect the area to be testing in advance in order to become familiar with the area.

4.54 Manpower

The average smoke testing crew consists of five persons. One person in charge (Maintenance Man II) and four observers and recorders (Maintenance Man I).

When there is a high flow in the pipeline to be tested and a chance of surcharging and overflowing an upstream manhole above the plugged off test section, a sixth person is needed to keep watch on the manhole.

When a manhole that must be watched appears to be subject to surcharge and overflow, use of a sandbag on a rope is perhaps the best answer. The sandbag plug may be pulled up long enough to allow the manhole to drain, then replaced as required. For best results, sandbags are tied in the middle so the chance of loss is decreased as much as possible.

Another method of closing off a pipe run for smoke testing where high flows exist is the use of curtains. These are pieces of canvas with weights on the bottom or a similar material with a rigid frame member along the top edge. They are lowered on a rope until they touch the surface of the flow and then they are tied in place. These curtains must be tight around the edges to prevent smoke leaks.

4.55 Operation

At the start of the operation, the smoke blower is located over the manhole and the ends of the pipes plugged at the next adjacent manholes. Smoke testing should not be attempted on windy days. Even a very light breeze can disperse a wisp of smoke before it is visible at a vent or the source of a leak.

1. The blower is started and allowed to force air into the pipe system for five to ten minutes or longer (depending on volume of sewer being tested) before any smoke bomb is lit.

   The purpose of forcing air into the pipe system is to get an air flow established. Since air has weight and inertia, it sometimes takes even longer than five or ten minutes to achieve a flow of air through a pipe system. Once a flow of air is properly established, the air will carry the telltale smoke along with it rather than have the blower try to push a wad of smoke into a pipe system.

2. Once the air flow is established, one or more smoke bombs are lit and lowered into the manhole at the blower on metal chains, or short lengths of wire. Hooks made of coat hanger wire are often used for this purpose.

   Smoke bombs have a cardboard cylinder with the smoke making chemicals inside and a single paper cover on the outside. The cardboard cylinder has perforations where the smoke escapes at frequent locations and these can be located with fingertip pressure. The perforated holes provide suitable places for a wire hook to be inserted in the smoke bomb.

3. As soon as the bomb has been lit and put into the manhole, the observers and recorders move out according to prearranged plans. One observer takes one side of the street and moves away from the manhole being smoked, observing the buildings on that side of the street. Another observer moves in the same direction on the other side of the street. The other two observers move in the opposite direction after inspecting the immediate area outside of the manhole.

   a. Where proper building plumbing exists, smoke will come from the roof vents of the building drain system.

   b. The observers must look at all other parts of the building (inside and outside) and its grounds (front, back and side yards) for other indications of smoke from illegal connections.

   c. Before moving on to the next house or building, the observer takes a careful look at the foundation of the building, particularly where the house service pipe would usually pass under the foundation footing.

4. The observer will cover one side of the distance between the manhole smoked and the next adjacent manhole that has been plugged.

5. In the event the smoke supply of the first bomb runs out before the area is fully observed, a second or additional bombs may be needed. One five-minute bomb is usually all that is needed (100,000 cubic feet of smoke) for a two-city block run, or approximately six hundred feet of pipe run. Where there are time comsuming conditions in the inspection process, as many as five or six bombs may be necessary.

4.56 Recording

Observers should record every building and the observed results of the smoke test. House numbers are generally sufficient for the recording purpose. Typical entries might include:

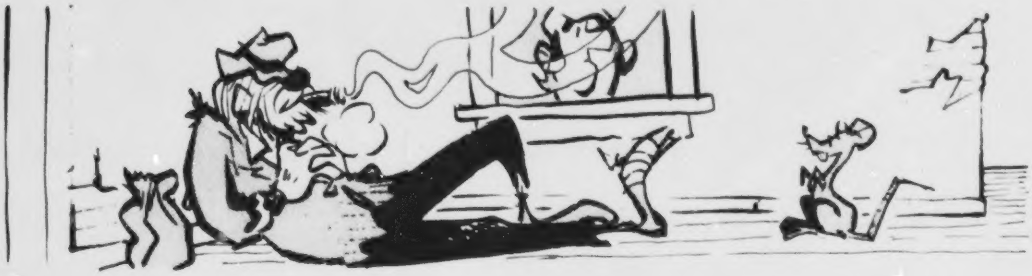
1. "265 Brown Street - smoke from vents only." This is a no-problem house as far as the smoke test was concerned.

2. "269 Brown Street - smoke from ground at building foundation, SE corner in front". This reveals what could be a source of inflow to the sewer as a result of the building sewer broken at the foundation. This is not uncommon when such pipes are laid shallow and often butted up under the house foundation. When the foundation settled, the pipe was crushed or disjointed.

3. "273 Brown Street - no smoke from vents." There may be a dip or a trap in the house sewer to the lateral. If none of the rest of the buildings beyond this house have smoke showing at vents, this is an indication that the lateral sewer has a dip in it that has created a trap. Another possibility would be a stoppage in the sewer that could result in wastewater backing up into the house.

4. "277 Brown Street - smoke from rain gutters." The roof leaders apparently are connected to the building drains. This is a source of inflow.

5. Any location where smoke is showing should be fully described and recorded. If smoke shows at the windows inside of an unoccupied building, it should be recorded with a note stating that the building appeared to be vacant or may have had occupants that were absent at the moment.



When this occurs, the observer should place a copy of the public announcement (Figure 4.25) where someone entering the house will find it. Letting such a person know that any odd odor found in the building could come from the sewer is a point of safety as well as concern. Also notify the health department or police to be sure corrective action is started immediately and that people are not allowed to live in the house until the problem is corrected. Making people vacate and stay out of a building is the responsibility of the health department and police department, not the job of the collection system worker.

Typical results from smoke testing are shown in Figures 4.26 and 4.27. Whenever possible, photograph illegal situations. Photos are a valuable record.

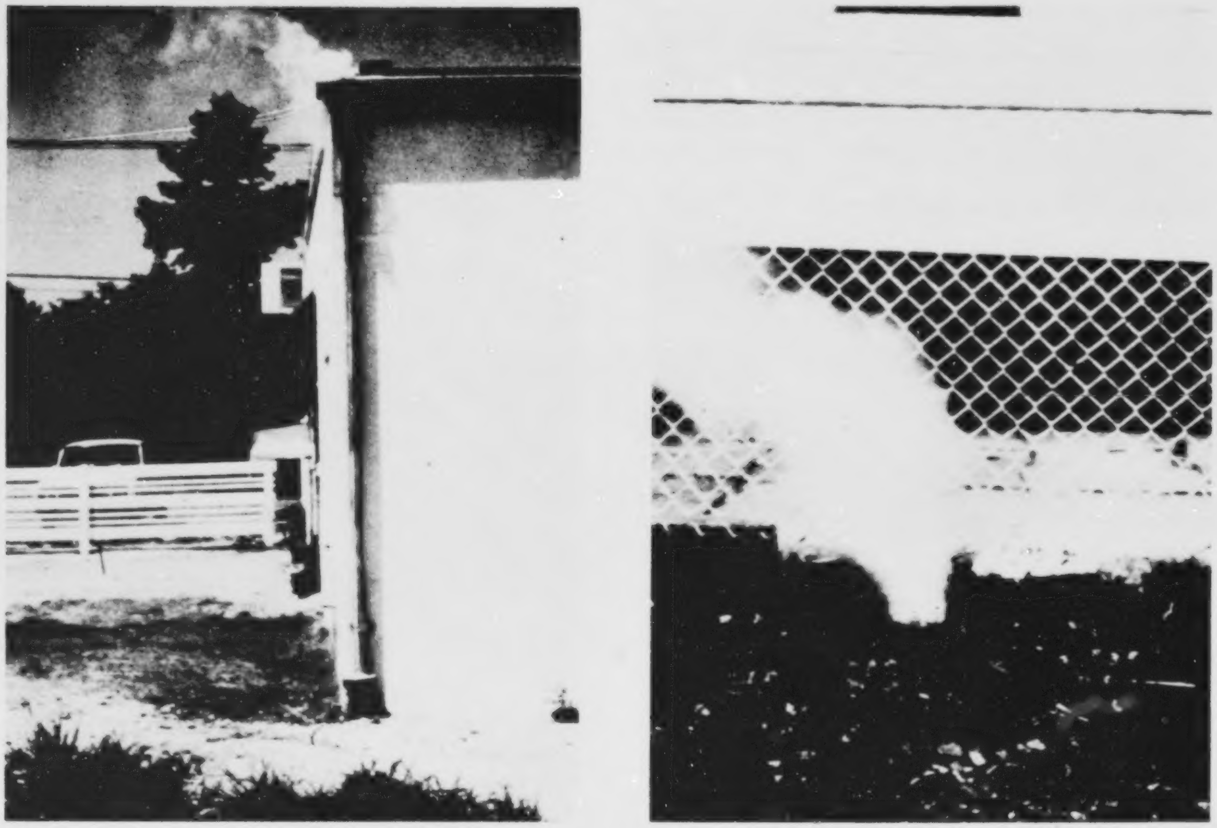
4.57 Other Considerations When Smoke Testing

1. Smoke testing may be used to locate points of inflow or exfiltration, but does not measure the amount of inflow or exfiltration.

2. Basement sump pumps have little chance of detection by smoke even when they have discharge connections to the building sewer. This is due to the usually required use of check valves in any sump pump tie-in to a building sewer and also the fact that the intake is submerged in water which forms a trap.

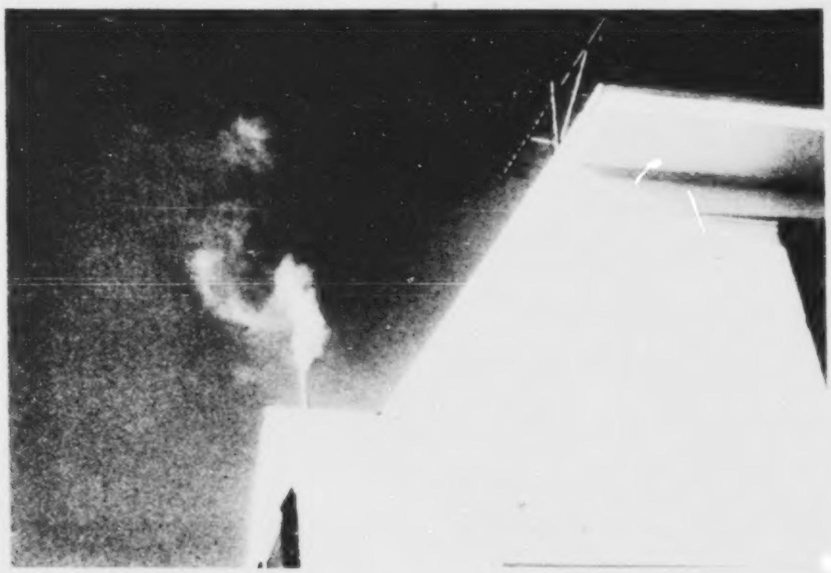
3. Where smoke appears at the vent pipe of a house, it is positive evidence that the house is connected to a sewer that is being smoked. Service districts which have monthly billings to property owners connected to a wastewater collection system thus have definite proof of a connection.

4. Where no smoke appears at a house vent, it does not mean that such a house is not connected to the sewer. Tests have shown that there are many houses with drain grade defects in service connection pipes, or may even have a trap installed in such a pipe. Many buildings that are connected to combined sewers have traps in the service line. Some buildings that may have been on a septic tank in the past may still be on such a tank with a connection from the discharge of the tank to the sewer. Under these circumstances, a well designed tank with baffles as required or an old tank with collapsed pipes and baffles may not permit the smoke to pass through.



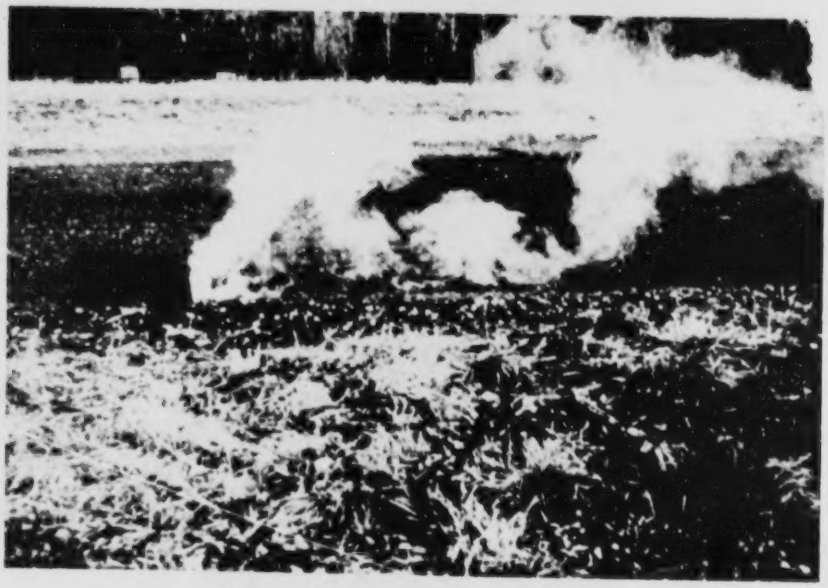
Building rain gutter connected to sewer system

Cleanout for building sewer that is uncovered and unsealed

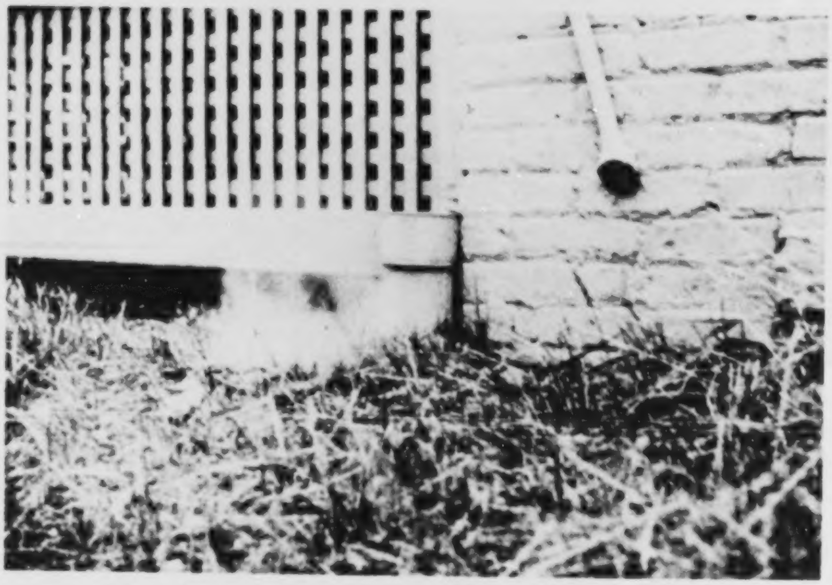


Smoke from building sewer vent indicates smoke test is effective

Fig. 4.26. Smoke test results



Smoke from yard drain illegally connected to wastewater collection system.



Smoke reveals the foundation settled and cracked or broke sewer pipe. Storm water from adjacent roof leader created open channel into the break in the sewer pipe.

Fig. 4.27. Smoke test results.

5. There are some cities and counties in the United States where modern enforcement of plumbing codes fails to adequately protect a service district. The admission of smoke into a building from sewer smoke testing usually indicates a health or plumbing code violation in the building's utilities. If smoke is found in a building, look for a dry trap from a basement shower, toilet or drain that has not been used recently before deciding there is a violation.

QUESTIONS

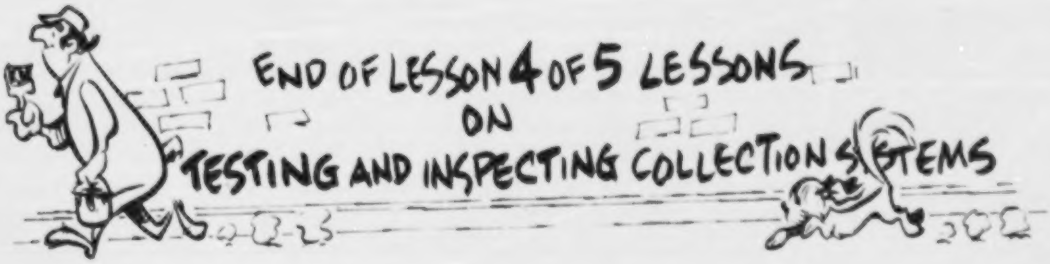
4.5A What is the purpose of smoke testing?

4.5B List the equipment needed for a smoke testing operation.

4.5C What preparations should be taken before starting a smoke testing program?

4.5D Why is the blower started and allowed to force air into the pipe system for five to ten minutes before a smoke bomb is lit?

4.5E Where should observers look for smoke?


END OF LESSON 4 OF 5 LESSONS
ON
TESTING AND INSPECTING COLLECTION SYSTEMS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 4 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 3.

19. Why are sewers smoke tested?

20. How would you handle a scared and irate citizen whose home was filled with smoke from a smoke testing operation?

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 5 of 5 Lessons)

4.6 DYE TESTING

4.61 Purpose

Dye testing is being used to establish positively if certain facilities or fixtures are connected to a wastewater collection system. Illegal connections can be identified using dye tests. If wastewater is overflowing or reaching a creek, river or estuary, dye testing can be used to identify the overflowing or leaking sewer. Also dyes are used to reveal interconnections between sanitary and storm sewers. Specially manufactured dyes are available for this type of testing. Examples of typical dye tests include:

1. Buildings that may not show smoke at vents during smoke tests due to dips or traps in the service connection pipes can be dye tested.
2. Where a yard drain or storm drain is suspected of being tied to the building sewer or a lateral sewer, a dye test is useful.
3. Any suspected situation of inflow or surface drainage may be checked out by using a dye.

4.62 Equipment

Contact the water pollution control agency to determine if there are any regulations regarding the use of dyes.

Two types of safe and harmless but effective dyes are available for dye testing. Powder in cans or containers is measured by a spoon or small dipper. Tablets of the dye are slower to dissolve than the powder form, but are less messy and are sometimes more desirable than the powder for this reason. The dye is the only piece of equipment needed. Regardless of the type of dye, dissolve it in the flow. A tablet may sink into a sump or wet well and not circulate with the usual flow.

CAUTION: Some dyes may leave a stain if spilled. These stains can be very difficult to remove.

4.63 Operation

While one worker applies the dye to the suspected location, another worker maintains a watch at the next downstream manhole from the location.

1. Where a plumbing fixture is used, such as a closet bowl or basin, the water is turned on and the dye powder or tablet is dropped directly into the drain.

2. Where there is no immediate supply of water, such as a roof gutter or storm drain in dry weather, pouring a bucket of water with dye powder is suggested. The amount of water and dye needed depends on the distance to the next manhole and the existing flow.

3. Based on an assumed velocity of flow, an estimate may be made of the expected flow time to the downstream manhole. Allow plenty of time because the dye often takes much longer than expected.

4. Use of a powdered dye can be difficult and messy on a windy day. When the wind blows, either pre-mix the dye in water or enclose a quantity of the powdered dye in either kleenex tissue or toilet paper. Once wind scatters a powdered dye, the dye is impossible to collect and nearby residents of homes and businesses can become very upset when the dye lands on their property, gets wet and causes stains on their buildings, autos, clothes and landscaping.

5. When the tests are completed, record whether or not the service is connected to the sewer.

QUESTIONS

4.6A What is the purpose of dye testing?

4.6B What equipment is needed for a dye test?

4.7 PIPELINE LAMPING[6]

4.71 Purpose

Lamping sewers from manhole to manhole has been done for many years. The purpose of lamping is to establish that a section of pipe is straight and open or that it is not. Lamping also permits an inspector to visually examine conditions in a pipe within viewing distance of the manhole, usually a very few feet in this case. Larger sewers are easier to lamp than small sewers.

4.72 Equipment

A bright source of light and a mirror are all that are needed for simple lamping. In some cases, two or more mirrors are used to direct sunlight from the surface of the ground, into the manhole to another mirror and then into the line.

4.73 Manpower

Four persons are usually needed for pipeline lamping, provided the two workers topside can easily contact the other if help is needed (1 Maintenance Man I and 3 Maintenance Man II).

4.74 Operation

Be sure the manhole is safe to enter by following the instructions in Section 4.1, Traffic and Manhole Safety.

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[6] Lamping. Using reflected sunlight or a powerful light beam to inspect a sewer between two adjacent manholes. The light is directed down the pipe from one manhole. If it can be seen from the next manhole, it indicates that the line is open and straight.

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14

1. One worker enters a manhole and either looks up the pipeline directly or looks up the sewer using a mirror. For smaller sewer lines, a mirror may be required. The worker in the manhole can use the mirror both to reflect sunlight and at the same time to look into the sewer.

2. A second worker enters the next manhole up or down the line and shines a bright light directly down the pipe towards the first worker. The light or mirror is moved around to be sure the light is directed down the pipe. If the first worker can see the light, the line is deemed to be open and straight. If the light is not seen, the line is deemed to be either 'off-line' or 'obstructed'.

3. When the first worker is able to see the light, a worker topside is notified who signals the crew directing the light. Signals or voice communications must be established between crews when the light is directed down the sewer and when it is seen at the other end of the sewer.

4. Best lamping results are obtained by rotating the light source around the inside of the pipe. This method will produce more information than a stationary light.

5. Another device used for lamping is an inverted (up-side-down) periscope with a changeable focal length from zero to 500 feet. A light source is introduced in the same manhole where the periscope is inserted. The results are quite graphic and the optical system can be calibrated to produce suitable readings within acceptable tolerances.

4.75 Comments

Lamping, while providing only limited information, has considerable value in collection system maintenance. It is an economical and fast method of determining if a line is straight and clear, or it will tell if there are imperfections in the line. Lamping is quick and cheap if it can be used. Where lamping is impractical with small sewers, the line usually can be balled without anyone having to enter a manhole to determine if there are any obstructions. In large sewers where the flow can be diverted or held, the sewer can be walked and inspected using a good light.

Lamping should never be used for any other purpose. The existence of cracks, infiltration or other pipe problems which do not affect pipe alignment are difficult to detect by this method.

QUESTIONS

4.7A What is the purpose of pipeline lamping?

4.7B Can lamping be used to locate sources of infiltration?

4.8 AIR AND WATER TESTING

If you have a need to test sewers for leaks using air or water testing methods, refer to the Supplement of Chapter 3, Section 3.7, Testing of Pipes.

END OF LESSON 5 OF 5 LESSONS
ON
TESTING AND INSPECTING COLLECTION SYSTEM

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 5 of 5 Lessons)

Write the answers to these questions in your notebook before continuing to the objective test on page 4-149. The problem numbering continues from Lesson 4.

21. What is the main reason for conducting a dye test instead of a smoke test?

22. Under what circumstances would you lamp a sewer?

SUGGESTED ANSWERS

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

4.0A Wastewater collection systems should be tested to:

1. Identify existing and potential problem areas,
2. Evaluate seriousness of detected problems,
3. Locate position of problems, and
4. Provide clear, concise, and meaningful reports to supervisors regarding problems.

4.0B Leaks are a problem because they allow

1. Infiltration that uses valuable capacity,
2. Exfiltration that could pollute ground water and surface water, and
3. Root intrusion into sewers.

4.1A Before setting up a work site in a street, be sure to contact the proper authorities. The authorities to be contacted will depend on local regulations.

4.1B Before inspecting, testing, cleaning or repairing sewers or manholes, you must SAFELY

1. Drive to job site,
2. Park vehicles,
3. Route traffic and pedestrians around the work site, and
4. Enter manhole if necessary.

4.1C Traffic can be warned and routed around persons working on a sewer in a street by the use of Hi Flags, warning signs, directional signs, barricades, flashers, traffic cones and flagmen.

4.1D Refer to Section 4.11 with sketches showing how to "Work beyond intersection" and "Closing right lane." Be sure to show location of Hi Flag and traffic cones.

4.1E Hazards one might encounter when entering a manhole include:

1. Atmospheric hazards,
2. Physical injury,
3. Infections and diseases,
4. Insects and biting critters,
5. Toxicants,
6. Drowning.

4.1F Atmospheric hazards encountered in manholes include:

1. Explosive or flammable atmospheres
    a. Methane gas
    b. Propane and explosive fuel gases
2. Toxic atmospheres, such as caused by hydrogen sulfide gas
3. Lack of oxygen

4.1G Physical injuries in manholes can be caused by

1. Restricted space
2. Uneven and slippery footing
3. Defective metal rungs for entry and exit
4. Dropping or tossing tools in and out of manholes

4.1H Personal cleanliness is the best means of protection from diseases when working in a manhole.

4.1I To protect yourself from insects when working in a manhole, always inspect the manhole before entry.

4.1J Safety equipment recommended for use when workers are required to enter a manhole include:

1. Self-contained breathing apparatus (use if necessary),
2. Safety harness with lifeline,
3. Portable oxygen/gas alarm unit,
4. Ventilation blower with hose,
5. Manhole enclosure,
6. Aluminum ladder or man lift,
7. Ropes and buckets,
8. Hard hats,
9. Protective clothing,
10. Cones and barricades,
11. First-aid kit,
12. Soap, water, paper towels and a litter bag,
13. Clean clothes.

4.1K The gas detection device should be either capable of continuously withdrawing samples of the atmosphere from the manhole or equipped with a probe or sensor that is lowered into the manhole and tests for (1) explosive or flammable gases, (2) hydrogen sulfide, and (3) percentage of oxygen. The device should have an audible or visual alarm that will warn when flammable gases exceed 20 percent of the lower explosive limit (LEL) or when oxygen drops below 19.5 percent.

4.1L Hydrogen sulfide gas is very toxic and commonly found in wastewater collection systems.

4.1M Before entering a manhole, the following preparations must be made:

1. Proper immunization of workers,
2. Contact medical officer in charge of any medical facility immediately upstream from any work site,
3. Healthy workers,
4. Spray inside of manhole with insecticide, if necessary,
5. Wash down manhole, if necessary,
6. Gather required tools, materials and equipment,
7. Test equipment,
8. Briefing.

4.1N Health conditions that should be considered before entering a manhole include:

1. Good health,
2. No hangover, not under influence of alcohol or drugs,
3. Good physical condition,
4. No open sores, infections, irritations.

4.1O Topics discussed during the briefing before manhole entry should include:

1. Safety aspects of job,
2. Order of doing tasks to accomplish job,
3. Emergency procedures.

4.1P The minimum crew when someone enters a manhole is three. One person enters the manhole and two must be standing by topside.

4.1Q Hold the lifeline. Carefully watch the person working in the manhole. The responses and actions can help indicate if the worker is suffering from lack of oxygen or fatigue. If there are any questions regarding safety, the worker should be brought up immediately.

4.1R The minimum level of oxygen in air for safe breathing is 19.5 percent.

4.1S After leaving a manhole, a worker should change clothes and wash thoroughly before going home.

4.2A The purpose of inspecting wastewater collection systems is to look for the causes of problems or the start of potential problems. Once a problem has been identified, its exact location must be determined. The size and kind of problem must be identified so the problem can be solved.

4.2B Major sources of wastewater collection system problems include:

1. Design related deficiences,
2. Improper installation,
3. Inadequate sewer-use ordinances,
4. Improper inspection and enforcement,
5. Changing patterns of population shifts and activities,
6. Disaster or contingency situations,
7. Problems of recurrent nature,
8. Problems characteristic of region,
9. Poor coordination between local agencies,
10. Problems related to a tired and frequently forgotten wastewater collection system.

4.2C Inflow and infiltration must be controlled to prevent hydraulic overloads of the collection system or the wastewater treatment plant.

4.2D The sources of inflow include (1) deliberate connections, and (2) surface drainage.

4.2E Sources of infiltration can be identified by the use of closed circuit television, flow metering devices, smoke testing, dye testing and visual inspection.

4.2F Infiltration problems can be corrected or eliminated by (1) sealing using pressure grouting, (2) digging up and replacing pipe, and (3) inserting a plastic liner.

4.2G Exfiltration must be controlled when it creates a problem such as the pollution of ground waters.

4.3A Manholes should be inspected to be sure the lid is at the proper elevation, the manhole is structurally sound and is performing its intended job.

4.3B One person can inspect a manhole, but assistance may be needed to route traffic or to enter the manhole.

4.3C When inspecting a manhole, examine the following items:

1. Elevation of lid,
2. Insects under lid or in manhole,
3. Surfaces and joints inside manhole
    a. Cracks or breaks
    b. Infiltration
    c. Joints
    d. Offsets
    e. Roots
    f. Grease
    g. Gravel or debris
    h. Turbulence
    i. Grout bed of frame
    j. Steps
    k. Shelf
    l. Flow
    m. Corrosion
4. Noises that indicate infiltration or turbulence from cracked or broken pipes,
5. Manhole ring,
6. Fit of lid.

4.3D Manholes should be inspected once every one to five years with those in areas of heavy traffic being inspected more often.

4.40A Testing and inspecting collection systems must be done thoroughly and on a regular basis to reduce the number of stoppages and failures.

4.40B Closed-circuit television inspection provides the opportunity to actually see the problems in a sewer, locate the problems, and evaluate the effectiveness of corrective action.

4.40C The following kinds of information can be obtained from a television inspection of a collection system.

1. Inspect conditions and determine location of problem areas,
2. Look for damage to sewers,
3. Search for unrecorded connections,
4. Locate inflow and infiltration,
5. Inspect installed and/or repaired taps or pipes,
6. Evaluate effectiveness of solutions and equipment.

4.40D A collection system televising crew usually consists of three people, plus additional help when working in heavy traffic and congested areas.

4.43A The TV camera should always be pulled from the upstream manhole to the downstream manhole for the sake of consistency. Also there is a lesser chance of the camera becoming stuck in older lines.

4.43B When a TV inspection crew arrives at a sewer to be inspected with a TV camera, safety should be their first consideration. Safety cones and flags should be properly placed to protect the crew and the equipment. The crew should wear hard hats, the manholes should be inspected for hazardous atmosphere and conditions, and the manholes should be ventilated.

4.43C The TV pull winch is located at the downstream manhole so the winch cable can pull the TV camera from the upstream to the downstream manhole.

4.43D The proper skids are important because the camera lens must be as close as possible to the center of the pipe when the camera moves down the pipe.

4.43E The pull winch cable is kept from rubbing on the pipe at the downstream manhole by the fair lead equipment. This equipment consists of a set of pulleys or jacks with pulleys placed in the manhole.

4.43F The footage meter should be set to read zero at the center of the manhole.

4.43G Two essential rules that must never be violated while the TV camera is moving down the line are:

1. The operator must never stop looking at the monitor picture. Any obstruction that could wedge or damage the camera or the light must be seen in time to stop the camera's progress.
2. If communications with the worker at the pull winch are lost, progress must be stopped immediately.

4.43H If a camera and skid assembly become wedged or locked in a pipe and the pull cables break, the pipeline must be dug up to recover the camera.

4.43I The TV camera must be stopped while the operator records data because the operator must stop looking at the TV monitor (screen) while writing the information.

4.43J A polaroid camera is used to photograph infiltration points, bad offsets, damaged laterals, root growths, and broken pipes. The photo provides an excellent record for supervisors to schedule repair work and for repair crews to visualize the problem to be corrected.

4.43K Some of the advantages of using a video tape over a polaroid camera include:

1. The operator's voice can describe the problem while people watch the picture.
2. The video tape records motion, such as infiltration flows.
3. If a pipe is off grade, the video tape can show the extent and magnitude of the defective area.

4.43L Conditions the TV camera may encounter which require special precautions include:

1. Offset joints that restrict the pipe diameter can cause a camera to wedge tightly in place.
2. When the TV camera goes under water it becomes impossible to see obstructions.
3. When the TV camera emerges from being under water, the picture can be foggy or indistinct which can reduce the effectiveness of the visual inspection.
4. Obstructions such as protruding service connections, objects sticking into the pipe, pieces of broken pipe, and roots require special consideration and care so the camera will not become wedged in the pipe.
5. If the camera is out of position, a properly designed camera and skid should right itself.
6. A foggy or indistinct picture, after getting a sharp picture in the pipe, indicates that the viewport and possibly the optical lens have become fogged.
7. An accumulation of grease on the light head.
8. Sewers flow more than half full and require a plug at the upper manhole.

4.43M A TV camera must NEVER be forced past an obstruction because if it becomes wedged tight, the line must be dug up to recover the camera.

4.43N When a TV camera encounters a bad joint that it cannot pass, the joint must be repaired before the remainder of the line can be televised.

4.43O If the viewport is very dirty with grease or other surface debris after being under water, there are three possible procedures for clearing the viewport.

1. Back the camera up until it is under water and allow it to sit for a minute or so to allow debris to be floated off.
2. Open a fire hydrant and discharge water into the upstream manhole in an attempt to wash away the debris.
3. Pull camera to downstream manhole, clean the viewport, and pull the camera back to where you wish to continue televising the line.

4.43P If a foggy or indistinct picture was observed shortly after the TV camera entered the pipe, try to determine what caused the problem and correct the situation. In this case, the glass in the lens was probably cold. Remove the camera from the pipe and try to warm the entire camera by placing it in a warm room, or behind or under a cardboard in the sunlight, or in a vehicle parked in the sun with the windows closed.

4.43Q Before turning in the television log sheet, every entry should be checked for readability, accuracy, and cleanliness.

4.43R The distance measured by the footage meter must be verified so all important distances recorded will be correct or can be corrected in order to help repair crews and future inspection crews.

4.43S The first act of the shut-down procedure is to turn off all power to the camera and light. Power must be off before anyone attempts to handle the camera or pull it out of the pipe. Shut off all switches before shutting down the generator to avoid low power damage to certain components of the camera and monitor.

4.43T Be sure the light assembly has cooled to a level that it can be safely handled before the viewport cover is installed on the camera.

4.43U The electrical contacts at the end of the power cables are protected from debris and moisture by placing a special cap or plug over the end of the contacts before the cable is retrieved back up the line.

4.43V To clean the tag line and power cable while they are being rewound, use a piece of foam rubber or a felt pad. Don't use a cloth with threads because pieces can be torn loose and wrap around the cables. Even a leather glove is not safe because small single strands of cable can break and stick out, scratch your hand, and cause a serious infection.

4.44A To select closed circuit TV equipment, talk to other collection system workers and consider their experiences and recommendations to help make a decision. If possible, arrange for a demonstration of the equipment being considered for purchase.

4.45A A photograph can be made of a problem inside a pipe by photographing the video picture in the television monitor or by using 3D photography.

4.45B Only high-speed black and white film should be used to take photos of the video picture in the TV monitor.

4.45C The most popular camera used to take photos of the video picture is the polaroid.

4.45D Information attached to a photograph should include:

1. Date,
2. Identification of line,
3. Footage location of the scene in the picture,
4. Log entry number (depends on record keeping system).

4.5A The purpose of smoke testing is to determine:

1. Source of entry to the collection system of surface waters,
2. Proof that buildings or residences are connected to a wastewater collection system,
3. Location of certain types of illegal connections,
4. Location of broken sewers,
5. Location of lost manholes.

4.5B Equipment needed for a smoke testing operation includes:

1. Smoke blower unit,
2. Pipe plugs (mechanical or inflatable),
3. Smoke bombs.

4.5C Before starting a smoke testing program, take the following precautions:

1. Warn the public in advance when and where smoke testing is planned.
2. Notify local fire and police departments.
3. Train all workers how to handle persons who discover smoke in their homes.
4. Prepare workers to respect the property and privacy of owners and occupants.
5. Discuss with city or agency attorney testing methods and possible adverse results.
6. Inspect area to be tested.

4.5D Air is forced into the pipe system by a blower five or ten minutes in advance to achieve a flow of air through the pipe system.

4.5E Observers should look for smoke from:

1. Roof vents,
2. Building foundations, especially where the house sewer passes under the foundation,
3. Drains from evaporation type coolers,
4. Yard drains,
5. Rain gutters,
6. Inside buildings.

4.6A The purpose of dye testing is to determine if certain facilities or fixtures are connected to the wastewater collection system such as:

1. Buildings that don't show smoke from vents during smoke tests.
2. Yard drains or storm drains.
3. Internal or surface inflow.

4.6B The only equipment needed for the dye test is the dye which is available in either powder or tablet form.

4.7A The purpose of pipeline lamping is to determine if a section of pipe is straight and open or not.

4.7B No, lamping should not be used to locate sources of infiltration or other pipe problems that do not affect pipe alignment.

OBJECTIVE TEST

CHAPTER 4. SAFETY, INSPECTING AND TESTING COLLECTION SYSTEMS

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

1. Closed circuit television is used by wastewater collection system workers to

    1. Look for sources of infiltration.
    2. Evaluate effectiveness of sewer cleaning and clearing techniques.
    3. Identify causes of stoppages after they have been cleared.
    4. Correct or verify "As-Built" plans.
    5. Reveal causes of continuous maintenance problems at a specific location.

2. Newly constructed collection systems must be inspected to

    1. Keep inspectors busy.
    2. Insure they will work properly before they attempt to convey wastewater.
    3. Determine if contractor has complied with plans and specifications.
    4. Look for sources of infiltration.
    5. Be sure agency receives a functioning system from the contractor.

3. Action taken as a result of a closed circuit television inspection of a collection system could include

    1. Establish priorities for corrective work in old pipes on an 'as needed' basis.
    2. Lamping the sewer.
    3. Implementation of a root control program.
    4. Notify supervisor home owners will not cooperate.
    5. Assignment of workers and equipment forms preventive maintenance and repair program.

4. What kind of information should be recorded during a TV inspection of a sewer?

    1. Potential or existing types or causes of stoppages.
    2. Defects in pipe.
    3. Date.
    4. Quantity of water to flush sewer.
    5. Distance from manhole to recorded observations.

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5. What factors or items could cause a TV camera to become wedged in a sewer if the operator is not careful?

   1. Saddles on sewers for service connections.
   2. Roots.
   3. Fair lead pulley.
   4. Protruding taps.
   5. Jumps or drops in the pipe.

6. What items should be considered when purchasing a closed circuit television camera?

   1. Recommendation of local TV appliance dealer.
   2. Experience of other nearby communities.
   3. Results from demonstration of equipment.
   4. Reputation of manufacturer.
   5. Cost to tie into community's commercial cable TV system.

7. Sewers may be tested for leaks by using

   1. Air.
   2. Water.
   3. Ammonia.
   4. Chlorine.
   5. Smoke.

8. Improper connections can be detected by

   1. Dye tests.
   2. Smoke tests.
   3. TV inspection.
   4. Policemen.
   5. Firemen.

9. Roots in sewers causing stoppages can be positively identified as the source of the problem by

   1. Smoke tests.
   2. Closed circuit television inspection.
   3. Observing roots in flow through a downstream manhole after clearing a stoppage with a power rodder.
   4. Dye tests.
   5. Observing trees growing over the sewer.

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10. Infiltration can be caused by

    1. Filtration pipes.
    2. Cracked pipes.
    3. Poor joints.
    4. Sealed joints.
    5. Root intrusion.

11. Infiltration can be controlled by

    1. Sealing cracks and joints in pipes.
    2. Balling the sewer.
    3. Repairing or replacing broken or cracked pipes.
    4. Inserting plastic liners or plastic pipes in the sewers.
    5. Regulating flows in pipe.

12. Items that must be checked before entering a manhole include

    1. Atmosphere in manhole.
    2. Equipment.
    3. Briefing on procedures.
    4. Health of worker entering manhole.
    5. Wash down of manhole if necessary.

13. After leaving a manhole, a worker should

    1. Use a deodorant.
    2. Go straight home.
    3. Turn on the blower to ventilate the manhole.
    4. Test for explosive gases and oxygen deficiency.
    5. Change his clothes and wash thoroughly before going home.

14. Types of defects that cause problems in wastewater collection systems include

    1. Structural failure of manholes.
    2. Joints poorly constructed.
    3. Improper grade of sewers.
    4. Design of facilities that hinder use of maintenance equipment.
    5. Use of material that fails under conditions existing in collection systems.

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15. When conducting a closed circuit television inspection of a sewer

1. Always pull camera from upstream manhole to downstream manhole.
2. Warn local residents that a TV camera will be in the neighborhood sewers.
3. Direct and divert traffic around workers and work area.
4. Never inspect camera, connections and cables with the power on.
5. Attach proper skids to camera to place lens as close as possible to the top of pipe so camera won't go under water.

16. While the TV camera is being pulled through the line,

1. The operator must never stop looking at the picture on the monitor.
2. Stop progress whenever communications are lost with other crew members.
3. The camera must never stop.
4. A coffee break can be taken.
5. The greater the drag on the cable, the harder the pull winch worker must pull.

17. Some of the advantages of a video tape recording system include

1. Cheaper than a polaroid camera.
2. Ability to see what's happening when camera is under water.
3. Visitors are impressed.
4. Motion of infiltration flows is recorded.
5. Length and severity of defective areas can be recorded.

18. Hazards that may be encountered by a TV camera going through a sewer include

1. Gases found in sewers.
2. Offset joints.
3. Deep water that submerges the camera.
4. Fogging of optical lens.
5. Grease on the head lamp.

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19. After a pipe has been inspected by the TV camera described in this chapter,

    1. Turn off all power to the camera and light.
    2. Install viewport cover on camera as soon as lamp assembly is cool.
    3. Disconnect power cables and protect electrical contacts from debris and moisture.
    4. Remove camera from downstream manhole.
    5. Clean camera, cables and equipment.

20. Items that must be examined when inspecting manholes include:

    1. Elevation of lid.
    2. Fit of lid.
    3. Cracks.
    4. Corrosion.
    5. Shelf of manhole.

APPENDIX

4.9 CLOSED CIRCUIT TELEVISION EQUIPMENT DETAILS

To review and evaluate an existing closed circuit TV inspection program or to consider starting a new program, the following steps can help you decide whether to purchase or rent equipment and select a manufacturer or contractor.

1. Make a list of the uses of the TV inspection program and information you wish to gain from the program.
2. List the important components of the TV inspection equipment and compare the equipment of potential manufacturers and contractors.
3. Compare economics, manpower, experience of others, maintenance requirements, and actual demonstrations and then select the best type of TV inspection program for your agency.

4.91 Uses of Closed Circuit TV

4.911 Inspection

1. Examine work completed by contractors.
2. Examine taps installed by a plumber or by maintenance crews.
3. Find and pinpoint inflow/infiltration and estimate amounts.
4. Locate unrecorded and/or illegal taps such as industrial, storm water or surface drainage.

4.912 Maintenance

1. Examine sewer problem areas such as pipe or joint rupture, condition of service connections, leaks, obstructions, corrosion and pipe alignment.

2. Look at a sewer line to determine what type of cleaning equipment would best solve a problem such as roots, grease or grit deposits.

3. Determine if equipment selected did the desired maintenance or repair job and produced cost effective results.

4. Review jobs done by repair crews fixing cracked pipe.

4.913 Rehabilitation tool

1. Grouting to control inflow/infiltration (see Chapter 6, Section 6.8, Polymeric Sealing).

2. Slip lining -- TV sewer prior to inserting a liner to look for protruding taps (see Chapter 6, Section 6.7, Polyethylene Pipe Lining).

4.92 Experience of Others and Observations from Demonstrations

One of the best ways to determine if a manufacturer can provide you with the TV equipment you need or if a contractor can provide you with the services you need, is to contact their previous clients. Talk to other collection system workers and consider their experiences and recommendations.

Always have the equipment manufacturers or contractors demonstrate their equipment. During the demonstration have the crews that will actually use the equipment try to use the equipment. Their comparisons of different equipment will be very valuable. If a contractor is demonstrating equipment, have the people who will use the results observe the demonstration and be sure they understand what is observed and what is recorded. Their comparison of the different contractors' ability to describe actual observations will be very helpful. If you are considering the purchase of TV equipment, try to rent the equipment first so you can evaluate the performance of the equipment and the results.

4.93 The Decision - Use a Contractor or Purchase Equipment

First the decision must be made whether to hire a contractor or to purchase closed circuit TV equipment. Important factors to evaluate include what needs to be televised, how long will it take, how much money is available and whether or not qualified workers are available to do the job.

The selection of a contractor or equipment manufacturer is usually based on the lowest qualified bidder. For this reason specifications must be carefully prepared and only qualified contractors or manufacturers allowed to submit bids. Recommendations and experiences of other agencies and the comments of persons participating in demonstrations should be considered when determining the qualifications of bidders.

4.94 Important Components of TV Inspection Equipment

Once the uses of a TV inspection program have been identified, the ability of the equipment of potential manufacturers and contractors to do the job can be compared. Important features of closed circuit television equipment that should be compared include:

4.941 Camera

1. Lighting requirements inside pipe
2. Pressure rating in psi
3. Type of connectors
4. Horizontal resolution
5. Type circuitry
6. Iris, focus, lens adjustments
7. Depth of field at various focal settings
8. Physical specifications - shock, vibration
9. Actual picture clarity

Television cameras for sewer line televising should contain selective features. To illustrate the type of information that should be obtained, the following list is provided:

1. Waterproof electrical and case assemblies to withstand pressure tests (external) up to 100 psi.

2. 600-line horizontal resolutions.

3. Synchronous crystal control.

4. 50 degree or greater wide-angle lens, maximum distortion not to exceed 2%.

5. Camera lens adjustments to be made through external means.

6. Camera viewport to be of optical grade quartz, not less than 3/8-inch thick.

7. Solid state electronic assembly, vidicon tube excepted, but with capacity to withstand three successive impacts of 25-Gs without damage.

8. Manufacturer to warrant camera (including vidicon tube) against defects in materials, parts, and workmanship for at least one year.

9. Manufacturer must provide adequate training for crew in field.

4.942 TV Cable

1. Tensile strength
2. Connectors
3. Length
4. Conductors, what kind, what size, how many

4.943 Video Monitor

1. Size of screen
2. Suited for mobile operation
3. Horizontal resolution
4. Video or RF

4.944 TV Cable Reel

1. Cantilever or axial mounted
2. Size
3. What type of rewind

4.945 Measure Meter

1. Accuracy
2. Placement of readout
3. Remote readout

4.946 System Control Unit

1. Protection circuits
2. Fuses
3. Circuitry - lights and camera
4. Input voltage, output voltage
5. Safety of unit

4.947 Light Head Assembly

1. Type bulbs required
2. Maintenance expected on unit
3. Lamp voltage

4.948 Skids and Tow Cables

1. Durability
2. Expected wear and tear
3. Serviceability
4. Pipe size range

4.949 Miscellaneous Items

1. Video input information devices
2. Manhole jacks
3. Surface rollers
4. Powerplants
5. Video tape equip.
6. Crew size

4.95 Economics

1. Initial cost and estimated life of TV unit
2. Expected maintenance costs
3. Crew requirements and labor costs
4. Expected production (feet of sewer televised per day and also feet televised per year)
5. Cost per foot (overall) of inspection
   a. Equipment Costs, $\$$/year = $\dfrac{\text{Initial Cost, \$}}{\text{Estimated Life of Unit, yr}}$
   b. Maintenance Costs, $/year
   c. Labor Costs, $/year
   d. Total Cost to Operate TV unit, $/yr - (a) + (b) + (c)
   e. Costs, $\$$/ft = $\dfrac{\text{(d) Total Cost, \$/yr}}{\text{(4) Expected Production, ft/yr}}$

CHAPTER 5

PIPELINE CLEANING AND MAINTENANCE METHODS

by

Dallas Hughes

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by Dallas Hughes

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OBJECTIVES

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

After completion of Chapter 5 you should be able to do the following:

1. Identify types and causes of sewer stoppages,
2. Select proper methods to clear stoppages and clean sewers,
3. Determine equipment and manpower requirements for various sewer clearing and cleaning methods,
4. Set up sewer clearing and cleaning equipment safely and properly,
5. Operate and maintain sewer clearing and cleaning equipment safely and effectively,
6. Clean sewers without flooding homes and basements,
7. Record essential data regarding clearing and cleaning operations,
8. Direct the following clearing and cleaning operaions:
    a. Balling
    b. High Velocity Cleaners
    c. Flushing
    d. Sewer Scooters
    e. Bucket Machines
    f. Power Rodders
    g. Hand Rods
9. Establish a preventive maintenance program for sewer clearing and cleaning equipment,
10. Develop a program to control odors and corrosion from hydrogen sulfide.

GLOSSARY

BALLING BALLING

A method of hydraulically cleaning a sewer or storm drain by using the pressure of a water head to create a high cleansing velocity of water around the ball. Normal operation provides for the ball to be restrained by a cable while water is allowed to wash past the ball at high velocity. Special sewer cleaning balls have an outside tread that causes them to spin or rotate, resulting in a 'scrubbing' action of the flowing water along the pipe wall.

BARREL BARREL

(1) The cylindrical part of a pipe that has a bell on one end.

(2) The cylindrical part of a manhole between the cone at the top and the shelf at the bottom.

BUCKET BUCKET

(1) A special device designed to be pulled along a sewer for the removal of debris from the sewer. The bucket has one end open with the opposite end having a set of jaws. When pulled from the jaw end, the jaws are automatically opened. When pulled from the other end, the jaws close. In operation, the bucket is pulled into the debris from the jaw end and to a point where some of the debris has been forced into the bucket. The bucket is then pulled out of the sewer from the other end, causing the jaws to close and retain the debris. Once removed from the manhole, the bucket is emptied and the process repeated.

(2) A conventional bail is used in 'bucketting out'.

BUCKET BAIL BUCKET BAIL

The pulling handle on a bucket machine.

BUCKET MACHINE BUCKET MACHINE

A powered winch machine designed for operation over a manhole and controlling the travel of buckets used to clean sewers.

BUCKETTING OUT BUCKETTING OUT

An expression used to cover removal of debris from a manhole with a pail on a rope. In balling or high velocity cleaning of sewers, debris is washed into the downstream manhole. Removal of this debris by scooping it into pails and hauling debris out is termed 'bucketting out'.

FLUSHING FLUSHING

The removing of deposits of material which have lodged in sewers because of inadequate velocity of flows. Water is discharged into the sewers at such rates that the larger flow and higher velocities are sufficient to remove the material.

HAND ROD HAND ROD

A sewer rod that can be inserted manually (by hand) into a sewer to clear a stoppage or to prevent a stoppage from developing.

HIGH VELOCITY CLEANER HIGH VELOCITY CLEANER

A machine designed to remove grease and debris from the smaller diameter sewer pipes with jets of high velocity water. Also called a 'Jet Cleaner', 'Jet Rodder', 'Hydraulic Cleaner', or 'High Pressure Cleaner'.

HYDRAULIC CLEANING HYDRAULIC CLEANING

Cleaning pipe with water under pressure that produces high water velocities.

(1) Using a high velocity cleaner.

(2) Using a ball, kite or similar sewer cleaning device.

(3) Using a scooter.

(4) Flushing.

KITE KITE

A device for hydraulically cleaning sewer lines. Resembling an airport wind sock and constructed of canvas type material, the kite increases the velocity of a flow at its outlet to wash debris ahead of it.

MECHANICAL CLEANING MECHANICAL CLEANING

Clearing pipe by using equipment that scrapes, cuts, pulls or pushes the material out of the pipe. Mechanical cleaning devices or machines include bucket machines, power rodders and hand rods.

ORIFICE (OR-i-fiss) ORIFICE

An opening in a plate, wall or partition.

POWER RODDER POWER RODDER

A sewer clearing machine fitted with auger rods which are inserted in a sewer line to dislodge and cut roots and debris.

PREVENTIVE MAINTENANCE PREVENTIVE MAINTENANCE

To perform the most effective maintenance procedure, in the area where it is most needed, at the proper time.

ROD (SEWER) ROD

A light metal rod, three to four feet long with a coupling at each end. Rods are joined and pushed into a sewer to dislodge obstructions.

RODDING RODDING

A method of opening a plugged or blocked pipe by pushing a steel rod or snake, or pulling same, through the pipe with a tool attached to the end of the rod or snake. Rotating the rod or snake with a tool attached increases effectiveness.

RODDING MACHINE RODDING MACHINE

A machine designed to feed a rod into a pipe while rotating it.

RODDING TOOLS RODDING TOOLS

Special tools attached to the end of a rod or snake to accomplish various results in pipe rodding.

ROTOMETER (ROW-tow-meter) ROTOMETER

A device used to monitor or meter the flow or application of chemicals.

SCOOTER SCOOTER

A sewer cleaning tool whose cleansing action depends on the development of high water velocity around the outside edge of a circular shield. The metal shield is rimmed with a rubber coating and is attached to a framework on wheels (like a child's scooter). The angle of the shield is controlled by a chain-spring system which regulates the head of water behind the scooter and thus, the cleansing velocity of the water flowing around the shield.

SEWER BALL SEWER BALL

A spirally grooved inflatable hard rubber ball designed for hydraulic cleaning of sewer pipes. (See 'BALLING').

STOPPAGE STOPPAGE

(1) When a sewer system becomes plugged and the flow backs up, it is said to have a 'STOPPAGE'.

(2) The place and cause of a stoppage. Example: "Fifty-one feet from a specific manhole" and "a grease stoppage".

(3) Partial or complete interruption of flow as a result of some obstruction in a sewer.

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 1 of 5 Lessons)

5.1 HOW TO IDENTIFY PROBLEMS AND SELECT SOLUTIONS

5.11 Objectives of a Sewer Cleaning and Maintenance Program

To operate and maintain a wastewater collection system so it will function as intended, try to strive towards the following objectives:

1. Minimize the number of stoppages per mile of sewer.
2. Minimize the number of odor complaints.
3. Minimize the number of lift station failures.

This chapter discusses how to identify the causes of stoppages and odors, how to select solutions to these problems, and how to actually solve these problems. Lift station problems and prevention of failures are presented in Chapter 7, Lift Stations, and Chapter 8, Equipment Maintenance.

5.12 Identification of Problem

Potential problems are often found during routine cleaning and maintenance. Our job is to try to prevent stoppages that will result in wastewater backing up and overflowing onto the street or into homes or businesses. Webster's Dictionary defines a stoppage as the act of stopping or arresting motion, progress or action; also, the state of being stopped or halted, such as an obstruction or a block in a water pipe. Therefore, we can consider a sewer stoppage to occur when a sewer system becomes plugged and the flow backs up.

5.121 Types of Stoppages

For the sake of recording stoppages for follow-up maintenance work, stoppages must be identified according to the cause or type of problem. Stoppages are caused by obstructions such as roots, grease, debris, broken pipe or a joint failure. These obstructions may require removal, repair, or replacement immediately to correct the problem.

Many stoppages are caused by people not realizing the consequences of their activities. For example, vandals have placed debris into lines and structure openings which were designed to vent the collection system. Also, they have placed materials or debris into structures designed for the purpose of performing maintenance work in the sewers. Manhole covers have been removed in isolated sewer easements by vandals. These openings offer an ideal place for vandals to cause a serious back up of wastewater in a very critical area.

Some stoppage problems created in sewer easement areas also may be caused unintentionally. This is especially true when a large piece of construction equipment begins rough grading work and this equipment knocks off the top of a manhole, spilling dirt, rocks, and other material debris into the opening and causing a stoppage in the sewer. In most cases, the equipment operator is not aware of the location of the manholes because they are buried or covered with overgrowth.

Other physical type stoppages are caused by obstructions found in the barrel[1] of the sewer. These obstructions are sometimes found to be created by plumbers, equipment, or by some force of nature. A plumber-made obstruction can be caused by the placement of a building sewer tap connection that protrudes into the main sewer, a poorly repaired pipe section, backfill damage to pipe and the misuse of trench compaction equipment, pipe damage due to the improper use of sewer cleaning equipment and other such physical contributions.

The forces-of-nature type of obstructions include the penetration of roots into the pipe connection or openings which cause pipe to break and/or restrict water flow. Ground movement shifting the pipe (such as caused by earthquakes), weather changes, soil conditions underground, and the deterioration of other utility pipes are effects caused by natural forces that could produce obstructions.

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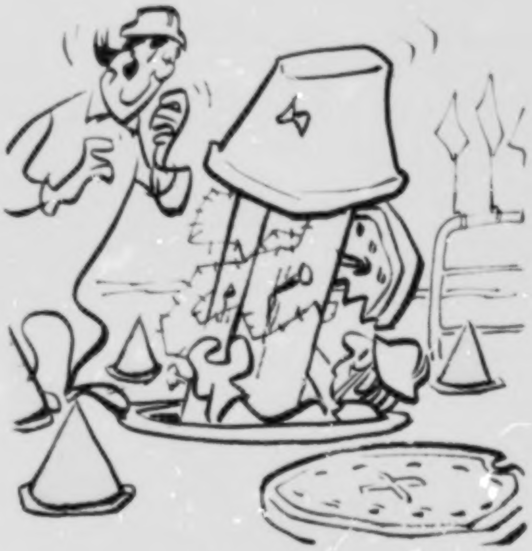
[1] Barrel. The cylindrical part of a pipe that has a bell on one end.

Some of the most common types of debris found when removing a stoppage are a build up of solidified grease, detergents, sticks, rags, plastic bags, broken pipe, brick, rocks, sand, eggshells and silt, to name a few. Larger items removed from lines and manhole openings which have caused a major problem for removal are broken manhole and flushing inlet castings; concrete and asphalt rubble; steel rebars; large metal and plastic buckets; broken and lost plumber rods, snakes and plugs; wooden posts and timber materials; barb wire; tree limbs, stumps and many other items.



In some instances where the invert of a small diameter sewer is connected to the invert of a large diameter sewer which is flowing at maximum flows, hydraulic conditions can cause serious stoppages to develop. Not only do stoppages develop in the sewer, but solids can build up in a manhole and produce harmful and obnoxious gases. Most instances of a hydraulic-caused-stoppage condition are found to be in sewers that have been extended to new developments from existing mains which were not designed for the future potential growth of a community.

Hydraulic-caused stoppages can be minimized by proper design. Wherever flows from one sewer meet and join the flow in another sewer, the flows should always be going downstream in the same direction as much as possible. A more frequent cleaning schedule is the best possible solution to hydraulic-caused stoppages in many cases.

5.122 Identifying Causes of Stoppages and Problems

First, try to correct the problem as quickly as possible. If the cause of the stoppage can be identified, the best method of correcting it comes next.

A mental check list to identify the problem would include:

1. Does this line have a history of previous stoppages? (A root problem line or a grease problem line.)
2. Are trees growing near the line?
3. Have new building sewers or new lateral or branch sewers been installed recently?
4. Have repairs been made recently to the sewer, to other utilities or to the street?

Once the cause of the problem has been identified, the methods for solving the problem can be analyzed.

QUESTIONS

5.1A To operate and maintain a wastewater collection system properly, what objectives should be considered?

5.1B What happens when a stoppage or blockage occurs in a sewer?

5.1C What are the major causes of stoppages?

5.1D How would you attempt to identify the cause of a stoppage?

5.13 Methods for Cleaning and Maintaining Sewers

Sewer cleaning and maintenance methods depend on the characteristics of the wastewater being conveyed to the treatment plant, fluctuations in wastewater flows, alignment on grade of the sewer, pipe material and condition of the sewer.

Stoppages can be cleared or prevented and sewers cleaned by either hydraulic or mechanical methods. Hydraulic cleaning methods consist of cleaning a sewer with water under pressure that produces high water velocities. These velocities are usually high enough to wash most grit, grease and debris found in sewers down the sewer and leave the pipe clean. Mechanical methods of clearing stoppages or sewers consist of using equipment that scrapes, cuts, pulls or pushes the material out of the pipe.

Hydraulic cleaning equipment used today includes high velocity cleaners, balls, kites, bags, parachutes, tires and scooters. High velocity cleaners rely on jets of high velocity water squirting from a nozzle at the end of a hose in a sewer. The high water velocity is very effective in cleaning sewers. High velocity cleaners also are called 'jet cleaner', 'jet rodder', 'hydraulic cleaner', or 'high pressure cleaner'. Balls, kites, bags, parachutes, tires and scooters all rely on the same principle. These devices fit into a sewer and partially block the flow. Water builds up behind the device and creates a pressure. This pressure forces water at a high velocity around the outside edge of the cleaning device. This high water velocity cleans the walls of the sewer and pushes the material and debris downstream where it can be removed at a manhole. Flushing is a hydraulic cleaning method that relys on additional water being discharged into a sewer in sufficient quantities to create high velocities and clean the sewer.

Mechanical cleaning equipment consists of bucket machines, power rodders and hand rods. A bucket machine operation includes a special bucket type of device that is pulled along a sewer. This device removes debris as it is pulled along the sewer. Rodding (by power or hand) consists of pushing or pulling a steel rod or snake through a sewer with a special tool attached to the end. Mechanical devices are more effective clearing than at cleaning and the sewers sometime have to be flushed after being cleared.

Both hydraulic and mechanical cleaning methods are used to maintain sewers in working condition. Chemicals also are used in sewer maintenance programs to keep lines clear.

Odor control (especially hydrogen sulfide control) requires that sewers be maintained as clean as possible. Hydraulic and mechanical cleaning methods as well as chemicals are used in odor control programs to maintain wastewater collection systems.

5.14 Selection of Solution to Problem

Some methods for cleaning sewers can be used for removing stoppages where others cannot. For specific jobs or routine preventive maintenance, different methods are available depending on whether the problem is caused by roots, grease, sand, or some other source.

Table 5-1 outlines:

1. How to identify problems and their source,
2. Methods of correcting these problems,
3. Section in manual where solution procedures are described in detail, and
4. Comments helpful for selecting the best method.

When you have a stoppage or flow problem in a sewer, try to identify the problem. Refer to Table 5-1 to see if the problem is listed. Review the methods of correcting the problem in the table, select a method, correct the problem, and evaluate the effectiveness of the solution.

This table cannot cover all problems or all equipment, but can be useful as a guide to effective and efficient collection system maintenance. The section after Table 5-1 outlines the equipment required for removing stoppages and cleaning lines, while the other sections in this chapter describe solution procedures in detail.

TABLE 5-1. CLEANING AND MAINTENANCE PROBLEMS AND SOLUTIONS

Identification of Problem	Source or Cause	Solution Method	Section	Comments
1. Stoppages - Emergency Condition a. Manhole overflowing b. Flooding of residences or businesses	1.a Grease	Hand Rods	5.33	Rod from downstream manhole with 4" auger into stoppage. When clear, then run 6" auger through restricted area. Write work request to high velocity clean line as soon as possible. If cannot open with hand rods, try high velocity cleaner.
		High Velocity Cleaner	5.22	Hand rods will usually unplug most grease stoppages. A high velocity cleaner will open most grease stoppages
	1.b Roots	Hand Rods	5.33	Rod from downstream manhole with 4" auger or saw. Be cautious in opening stoppage if there is a high head on the upstream manhole. Remove as much of the root mass as possible. Request TV inspection for root concentration; schedule power rodding to open line and chemical treat to control future root growth. Hand rods are effective 90% of the time. If cannot clear roots with hand rods, try high velocity cleaner.
		High Velocity Cleaner	5.22	High velocity cleaner will usually open stoppage and restore service. Schedule TV check and treatment. If unable to clear roots with high velocity cleaner, try power rodder.
		Power Rodder	5.32	Power rod line to clear stoppage. Schedule TV check, cleaning, and chemical treatment.

Identification of Problem	Source or Cause	Solution Method	Section	Comments
	1.c Debris Stoppage Such as Rocks, Lumber			Caused by broken lines, open manholes, vandalism.
		High Velocity Cleaner	5.22	Clean line with high velocity cleaner.
		Power Rodder	5.32	Use caution. May jam tool in line requiring a dig up to clear line and remove broken rod and tool.
2. Grease a. Stoppage Causes Grease Build up	a. Restaurant on Blocked Segment of Sewer	a. High Velocity Cleaner	5.22	High velocity cleaner is an effective tool in removing grease build ups in line sizes up to 15 inches. High velocity cleaner becomes ineffective in larger diameter pipes.
b. TV Report on Routine Inspection	b. Low Velocity Allowing Grease Build up From Home Disposal Unit Problems Often Develop where High Velocities are Suddenly Slowed Down	b. Balling	5.21	Balling will remove grease deposits from pipe walls, but will not clean walls as effectively as high velocity cleaner if used properly.
c. Observe Build up on Side Walls of Sewer		c. Scooter (or kite)	5.24	More effective in lines above 18-inches diameter than high velocity cleaner.
d. Past Records		d. Power Rodder	5.32	Extensively used, but not as effective in grease removal as high velocity cleaner and balling - usually ineffective in lines above 10 inches.

Identification of Problem	Source or Cause	Solution Method	Section	Comments
		e. Chemicals	5.54	Be sure to insist on a performance contract. Do not pay until the chemical or material performs as claimed.
e. Grease Trap		a. Clean Trap Regularly	5.54	A regular maintenance program must be establisned and continued.
3. Roots a. TV Report	a. Trees and Shrubs	a. Chemicals	5.5	For long-term control, chemical treatment provides the best solution with up to three years between application rates.
b. Poor Joints or Damaged Pipe Allow Root Entry c. Past Records		b. Power Rodder	5.32	May be used to clear an opening so that flow may pass. Cutting roots is like pruning shrubs, it stimulates root growth. If power rodding is only control used, must frequently redo that segment of line.
		c. Repairs	Chap. 6	If TV report shows only one section of broken line or a few bad joints, dig up and repair. If a great number of defects are observed, consider pressure sealing or relining the pipe by insertion of a liner.
4. Sand, Grit, Debris a. TV Report	a. Eggshells, coffee grounds, bones from residential disposal units	a. High Velocity Cleaner	5.22	For light concentrations of grit in small lines, not effective in lines above 15 inches.

Identification of Problem	Source or Cause	Solution Method	Section	Comments
b. Grit Settles During Low Flows		b. Balling	5.21	The work horse for cleaning. Large volumes can be removed at a reasonable cost. Requires careful control in shallow lines. Not manageable in sewers larger than 24 inches.
c. Grit Sticks to Grease or Slimes	b. Broken china, bones, and glass from restaurant disposal units.	c. Scooters and Kites	5.24	More effective in larger lines. Removes some dangers of flooding in shallow lines that balling may create if not properly controlled.
d. Routine Inspection				
e. Past Records	c. Sand, silt from poor joints and broken lines	d. Bucket Machines	5.31	Used where extreme concentrations of grit and sand have loaded the line to extent that above methods are ineffective due to cost and handling of material to be removed.
	d. Lines with low flows or velocities permitting deposition of solids			
5. H_2S and Odor Control	a. Force Mains	a. High Velocity Cleaner	5.22	Fast cleaning of slimes in lines up to 15 inches.
a. Odor Complaints	b. Low flows and velocity	b. Balling	5.21	Best for sewers with bellies and offset joints in lines up to 24 inches, but expensive operation for odor control only.

Identification of Problem	Source or Cause	Solution Method	Section	Comments
b. Manhole Inspection reveals line deterioration	c. Offset Joints	c. Scooter	5.24	Fast for larger lines.
	d. Bellies in Line	d. Flushing	5.23	Small lines. Usually not effective for more than one week.
	e. Drop Manholes	e. Plug Lifting and Vent Holes in Manhole Cover		Roofing cement makes a satisfactory hole sealer.
	f. Manhole where trucks dump septic tank contents	f. Control Program	5.6	Develop program using combination of solutions.
6. System Inspection	Detect problem areas and permits realistic scheduling of preventive maintenance program	a. Closed Circuit TV	4.4	Permits thorough inspection of system. Pin-points damaged areas such as broken pipe segments, offset joints, lines not to grade, collapsed pipes, protruding service taps, root intrusion, deterioration of lines, and grease deposits. Informs you of required cleaning and the effectiveness of the cleaning method. If a stoppage reoccurs or you are curious regarding cause of problem, TV the line. The most useful tool in collection system maintenance.
		b. Air and Water Testing	3.7	Detection of sources of infiltration and exfiltration.

entification of Problem	Source or Cause	Solution Method	Section	Comments
b. Manhole Inspection reveals line deterioration	c. Offset Joints	c. Scooter	5.24	Fast for larger lines.
	d. Bellies in Line	d. Flushing	5.23	Small lines. Usually not effective for more than one week.
	e. Drop Manholes	e. Plug Lifting and Vent Holes in Manhole Cover		Roofing cement makes a satisfactory hole sealer.
	f. Manhole where trucks dump septic tank contents	f. Control Program	5.6	Develop program using combination of solutions.
System Inspection	Detect problem areas and permits realistic scheduling of preventive maintenance program	a. Closed Circuit TV	4.4	Permits thorough inspection of system. Pin-points damaged areas such as broken pipe segments, offset joints, lines not to grade, collapsed pipes, protruding service taps, root intrusion, deterioration of lines, and grease deposits. Informs you of required cleaning and the effectiveness of the cleaning method. If a stoppage reoccurs or you are curious regarding cause of problem, TV the line. The most useful tool in collection system maintenance.
		b. Air and Water Testing	3.7	Detection of sources of infiltration and exfiltration.

Identification of Problem	Source or Cause	Solution Method	Section	Comments
		c. Smoke Testing	4.5	Locates leaks when ground water table is below sewer. Also used to determine if buildings and residences are properly connected to collection system and to identify illegal connections.
		d. Dye Testing	4.6	Identification of illegal connections and location of overflowing or leaking manholes and sewers.
		e. Pipeline Lamping	4.7	Inspection of sewers for condition, including alignment and obstructions.
		f. Visual	4.3	Lift manhole covers and observe conditions.

5.15 Equipment Required for Removing Stoppages and Cleaning Sewers

What type of equipment is best suited for removing stoppages and cleaning sewers? The answer to this question can only be determined after an analysis of the cause of the problems and the solution selected. Following is a list of the basic types of equipment used to identify and remove stoppages and clean sewers:

5.151 Rodding

Equipment: Power rodder machine (may be truck or trailer mounted) or hand rods.

Advantages: May be used to cut roots, scrape, and dislodge and remove certain types of material found in sewers. This equipment is very effective in removing collection line emergency stoppages.

Limitations: Ineffective for removing sand and grit accumulations in sewers, but may loosen material so it can be flushed out of sewer. Rods have a tendency to coil and bend when used in large diameter sewers.

5.152 Sewer Ball

Equipment Assortment of various sizes of sewer balls to fit different diameters of sewers, tag line winch, cable, reels, water tank truck, and dump pickup.

Advantages: Hydraulic action of spinning ball and high velocity of water flowing around ball dislodges debris from pipe walls and moves debris downstream. Very effective in removing heavy concentrations of sand, grit, rock and grease from sewers.

Limitations: Dangerous to use in locations with basement fixtures and steep-grade hill areas. Prevalent possibility of flooding dwellings. Cannot be used effectively when sewers have bad offset joints or protruding service connections because ball can become distorted, get past these obstructions and not do an effective cleaning job. In sewers where the ball has a tendency to get stuck, a bag full of ice can be used. When the bag becomes struck, wait for the ice to melt sufficiently for the bag to continue downstream.

5.153 High Velocity Cleaner

Equipment: Truck mounted high velocity water machine, manhole hose guide, debris traps, and dump pickup or debris trailer.

Advantages: Very effective in cleaning flat, slow flowing sewers. Efficient in removing grease, sand, gravel, and debris in smaller diameter sewers. Effective in breaking up solids in manholes and washing structures. May be used to remove emergency stoppages.

Limitations: Efficiency and effectiveness in removing debris from larger diameter lines decrease as the cross-sectional area of the pipe is increased. This method, when used by an inexperienced operator, may cause a back up into residences.

5.154 Bucket Machine

Equipment: Power bucket machine, power bucket truck loader, dump truck, and manhole jacks.

Advantages: Removes large amounts of sand and debris from larger diameter sewers, but may leave as much as it removes. A sewer should be cleaned by other methods after being cleared with a bucket machine.

Limitations: Can damage sewers. Setting up equipment is time consuming.

5.155 Kite or Bag

Equipment: Water tank truck, dump pickup truck, and power drum winch machine.

Advantages: Very effective in moving accumulations of decayed debris and grease downstream. Capable of washing ahead of it a full pipe of deposits, including roots.

Limitations: Must use caution in locations with basement fixtures and steep-grade hill areas.

5.156 Scooter

Equipment: Water tank truck, dump pickup truck, tag line, and power winch.

Advantages: Hydraulic water action scours inside of line. Very effective in removing heavy debris and cleaning grease from line.

Limitations: When cleaning larger lines, the manholes must be designed to a larger size to receive and retrieve this equipment. Must use caution in locations with basement fixtures and steep-grade hill areas.

5.157 Flushing

Equipment: Water tank truck and fire hose if fire hydrant is not convenient.

Advantages: Supplies a surge of water to move light, decaying organic matter in slow flowing sewers downstream.

Limitations: Causes a temporary movement of debris from one point to another in the collection system. Flushing does not remedy the cause of the problem and does not move heavy debris and grit. Must use caution in locations with basement fixtures and steep-grade hill areas.

5.16 Summary of Solutions

Table 5-2 shows the relative effectiveness of the possible solutions to different problems. The larger the size of the box in the square, the more effective the solution is for a particular problem. One problem may have several effective solutions and another problem may have only one possible solution. REMEMBER that Table 5-2 is a summary table to provide you with an indication of the general effectiveness of solutions. YOU must evaluate every problem and select the best solution using available equipment.

TABLE 5-2. EFFECTIVENESS OF SOLUTIONS

SOLUTION TO PROBLEM	TYPE OF PROBLEM				
	Emergency Stoppages	Grease	Roots	Sand, Grit Debris	Odors
Balling[1]		☒		☒	☒
High Velocity Cleaning	☒	☒		☒	☒
Flushing					☒
Sewer Scooters		☒		☒	
Bucket Machines				☒	
Power Rodders	☒	☒	☒		
Hand Rods	☒[3]	☒	☒		
Chemicals[2]		☒	☒		☒

1. Kites, tires, bags, parachutes, and cones are commonly used instead of balls in larger sewers (greater than 24 inches in diameter) with similar results.

2. Effectiveness depends on type of chemical and its intended use.

3. Power rodders and high velocity cleaners may be faster (if available) under certain conditions.

5.17 Work Assignment

When a crew is assigned a regularly scheduled sewer cleaning job, the crew should be notified and dispatched by a written order (see Chapter 6, Section 6.15, Work Request Form). Crews assigned to clear emergency stoppages are notified by radio and immediately attempt to clear the stoppage. A written report is prepared after the stoppage is cleared. Work performed also must be recorded. This information provides vital documentation of the ability of the wastewater collection system to perform its intended job and also the effectiveness of equipment and crews. Chapter 10, Section 10.2, Records, provides a discussion of the need for records and the value of records.

The crew chief for most cleaning operations is the Maintenance Equipment Operator.[2] The chief receives the work assignments for the day from a Maintenance Supervisor I (depends on size of agency who prepares and makes work assignments). Work assignments should include the following information for each location:

1. Location of job, including map book number, map page and manhole number.
2. Street or easement.
3. Location of upstream and downstream manholes.
4. Line-of-sight or sound-powered telephone communications.
5. If in street, traffic conditions, or
6. If in easement,
    a. Notification of property owners.
    b. Are dogs locked up?
    c. Keep children out of work area.

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[2] Portions of this section and job titles are from "Manpower Requirements for Wastewater Collection Systems," by Elie Namour for EPA, Grant No. 900211, March, 1974.

7. Sewer conditions.
    a. Size.
    b. Depth.
    c. Water supply needed.

Upon arrival at the work site, the sewers to be cleaned are located using a map.

5.18 Records

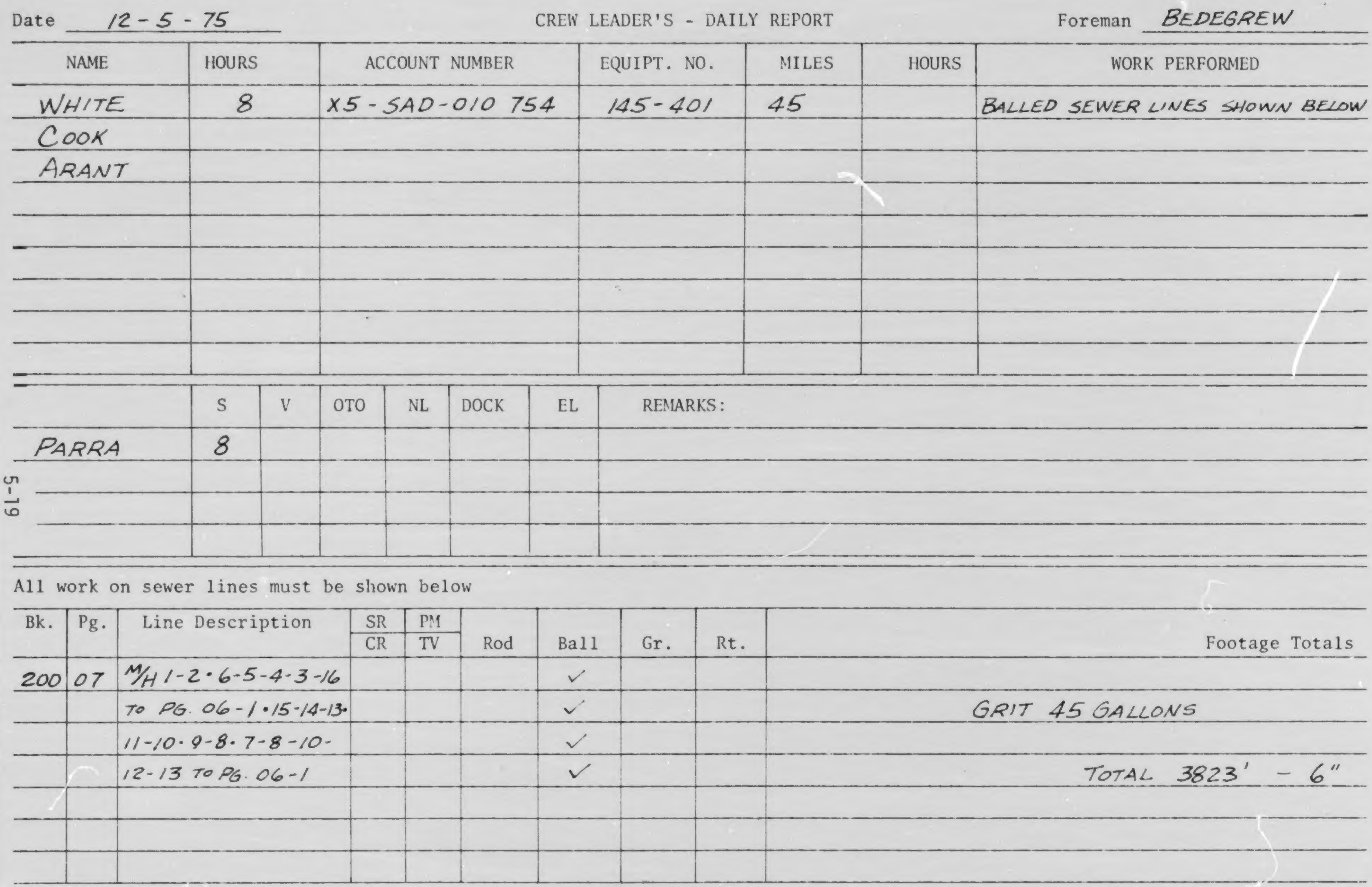
A record of all cleaning operations should be made (Figure 5.1) and filed for future reference. These records should include the date, street name or number, line size, distance, and manhole numbers or identification. Also note the kind and amount of material removed, wastewater flow, and amount of auxiliary water used. If particular problems were encountered, these too should be noted, especially exact location of obstructions. See Chapter 10, Section 10.2, Records, for details on how to prepare record forms, complete forms (Figure 5.1), analyze records, and file records.

If pieces of broken sewer are removed, this may indicate a TV inspection is needed and a repair made on the broken sections of pipe.

When making out records, remember that you or someone else will be referring to them. The more complete the record, the easier the next operation becomes since you have a history of this sewer.

5.19 Notify Wastewater Treatment Plant

After clearing a large septic stoppage, be sure to notify the operator on duty at the downstream wastewater treatment plant. Septic stoppages develop when the sewer has been blocked for considerable time and/or the air temperature is hot. Under these conditions the wastewater and organic solids turn black and smell like rotten eggs. If a large diameter sewer is blocked and



Date 12 - 5 - 75 CREW LEADER'S - DAILY REPORT Foreman BEDEGREW

NAME	HOURS	ACCOUNT NUMBER	EQUIPT. NO.	MILES	HOURS	WORK PERFORMED
WHITE	8	X5 - SAD - 010 754	145 - 401	45		BALLED SEWER LINES SHOWN BELOW
COOK						
ARANT						

	S	V	OTO	NL	DOCK	EL	REMARKS:
PARRA	8						

5-19

All work on sewer lines must be shown below

Bk.	Pg.	Line Description	SR CR	PM TV	Rod	Ball	Gr.	Rt.	Footage Totals
200	07	M/H 1-2·6-5-4-3-16				✓			
		TO PG. 06-1·15-14-13·				✓			GRIT 45 GALLONS
		11-10·9-8·7-8-10-				✓			
		12-13 TO PG. 06-1				✓			TOTAL 3823' - 6"

Fig. 5.1. Daily maintenance report

a considerable volume of wastewater backs up in the pipes, there might not be sufficient fresh water arriving at the treatment plant to dilute the septic wastewater. When a large volume of septic wastewater reaches a treatment plant, the treatment processes can become upset and fail to do their intended job. By notifying the operator in advance of the location of the stoppage and approximate volume of septic wastewater flowing towards the treatment plant, the operator can be alerted and get prepared to minimize the impact on the treatment processes.

QUESTIONS

5.1E When a grease or root stoppage causes flooding, what is the first method attempted to solve the problem?

5.1F What is the most effective method of removing grease build ups?

5.1G How can a stoppage caused by roots be cleared?

5.1H List the advantages and limitations of a high velocity cleaner.

END OF LESSON 1 OF 5 LESSONS
ON
PIPELINE CLEANING AND MAINTENANCE METHODS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 1 of 5 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. Why should the cause of a stoppage be identified?

2. What are the causes of stoppages?

3. How would you select a method to clear a stoppage?

4. What are the advantages and limitations of sewer balls in comparison with other methods of cleaning sewers?

5. How would you determine if a sewer needed cleaning?

6. What would you do if you encountered an emergency stoppage with wastewater flowing out a manhole and down the street?

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 2 of 5 Lessons)

5.2 HYDRAULIC CLEANING

Sewer cleaning methods described in this section rely on the cleansing action caused by high velocities of water in the line. High water velocities can effectively remove grease, sand, and other debris. Cleansing velocities can be obtained by allowing water pressures or head to build up in the line or by using a pump to produce the water pressure. Hydraulic cleaning methods include balling, high velocity cleaners, flushing, sewer scooters, kites, tires and poly pigs.

WARNING

WHEN USING THESE METHODS, CAUTION **MUST** BE TAKEN TO BE SURE BASEMENTS AND HOMES ARE **NOT** FLOODED

QUESTIONS

5.2A List three sewer line hydraulic cleaning methods.

5.2B What is a major precaution that must be exercised when hydraulic cleaning methods are being used?

5.21 Balling

Balling is one method of removing debris from sewers. The tool is literally a "ball" of special design (Figure 5.2).

This cleaning procedure is one of the less expensive methods and is quite popular in some cities. Usually balling is not the only cleaning method used by a sanitation agency since the ball primarily removes deposits of inorganic (grit) material lying on the bottom of the line and grease build-up inside the line. Balling can be used only in areas where the necessary water pressure behind and around the ball can be obtained without flooding basements or homes at low elevations. Flooding can occur when the elevation of the head of water on the upstream side of the ball is higher than a plumbing fixture in a home or basement. If many roots are involved, a power rodding machine probably will be needed. Power rodding and other cleaning methods and procedures will be discussed fully in other sections of this chapter.

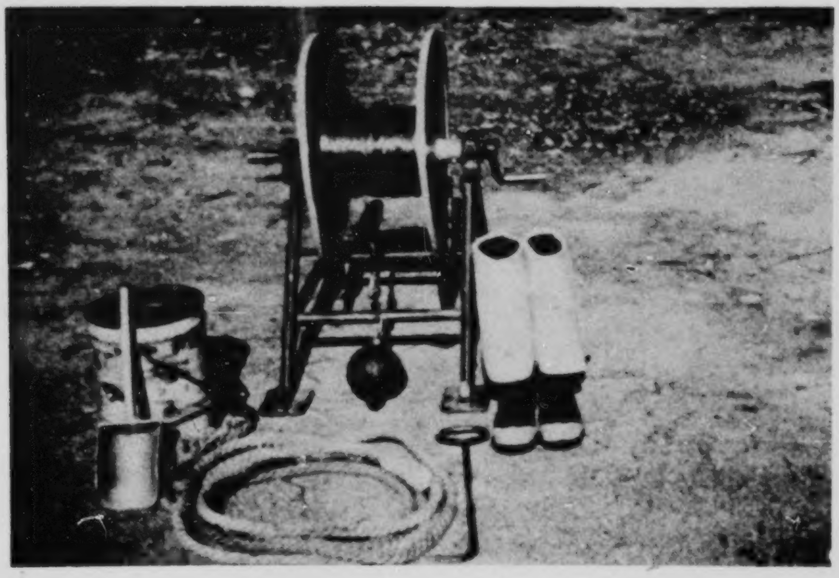
Balls are available in sizes 6, 8, 10, and 12 inches for small lines and sizes up to 48 inches for large trunk lines.

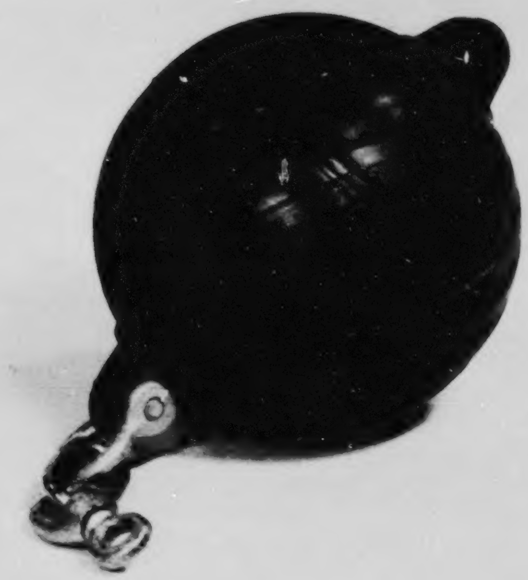
Balling is most commonly used in preventive maintenance programs. Under these conditions balling is very effective in reducing the possibility of stoppages developing. An effective balling program can reduce the production of hydrogen sulfide (see Section 5.6, Hydrogen Sulfide Control) in collection systems, thus reducing damage from hydrogen sulfide caused corrosion and the release of odors smelling like rotten eggs.

Some sewers require cleaning by balling more frequently than others. Required frequency of cleaning may vary from six months in some sluggish lines, to three years in other lines. Realize that these are typical frequencies and that some sewers may require monthly cleaning while other sewers may never need cleaning. Many communities try to ball their entire collection system every year. To determine the frequency of balling for your collection system, study your agency's records. Base the frequency of cleaning the various sections of the collection system upon:

a. Reducing the number and types of stoppages and complaints by analyzing records and inspecting manholes for the presence and amount of deposits.

b. Size of area the collection system serves.





Sewer Ball
(Courtesy of the SIDU Company)

Fig. 5.2. Sewer ball and balling equipment

c. Types of waste carried by collection system:

1. Residential
2. Commercial
3. Industrial
4. Storm water

The main purposes of balling are to keep the sewer clear of debris and to maintain flow velocities of two feet per second or more in the sewers to the wastewater treatment plant.

5.211 Manpower and Equipment

At least three workers are needed for cleaning lines up to 10 or 12 inches. When cleaning those lines located in easements or off the street, additional help may be required depending on the difficulty of the job. Manpower requirements[3] are as follows:

1. Maintenance Equipment Operator
2. Maintenance Man I
3. Maintenance Man I

Although some of the equipment listed below is used for balling, the majority of collection system maintenance departments will have most of the regular tools needed. Basic essentials include:

1. Water truck holding 1,000 or 2,000 gallons
2. Tag line and a suitable reel to store it on (Figure 5.2).

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[3] Job titles in this manual are from "Manpower Requirements for Wastewater Collection System," by Elie Namour for EPA, Grant Award No. 900212. See Special Notice on page x at the beginning of this manual for additional information regarding job titles.

3. Manhole jack or roller.

4. Plugs.

5. Balls (Figure 5.2).

6. Equipment truck.

7. Debris and grit trailer.

8. Ladder.

9. Manhole bars or lifters (Figure 5.3). (Manhole hooks (Figure 5.2) can cause back injuries if not used properly.)

10. Buckets, rope and manhole shovel.

11. Hip boots and gloves (Figure 5.2).

12. Sound powered telephones.

13. Collection system map.

14. Waterless hand cleaner and hand towels.

15. Safety equipment. (See Chapter 4, Section 4.1, Traffic and Manhole Safety.)

Some communities use domestic water from fire hydrants instead of a water truck to obtain water to provide the necessary head for a balling operation. If fire hydrants are used, the following additional equipment will be needed.

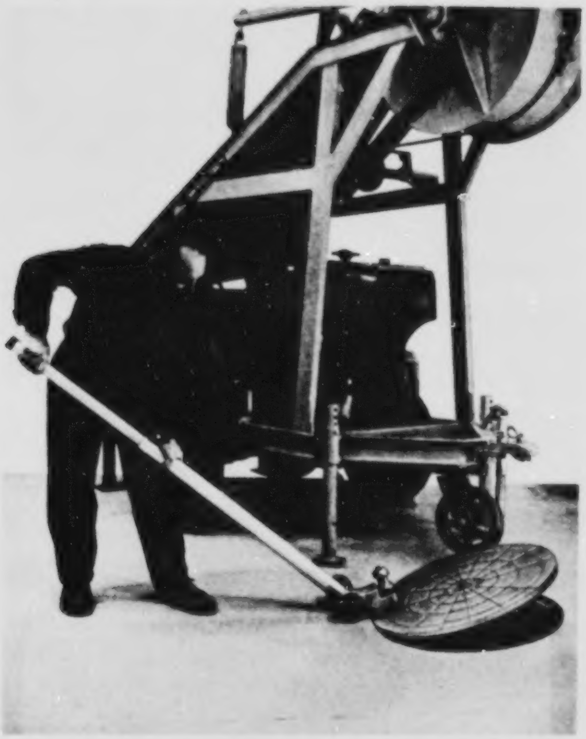
1. Five to eight 50-foot lengths of 2.5-inch fire hose.

2. Hydrant wrench.

3. Water meter.

4. Control valve for regulating flow at manhole.

5. Traffic ramp to protect hose (Figure 5.4).



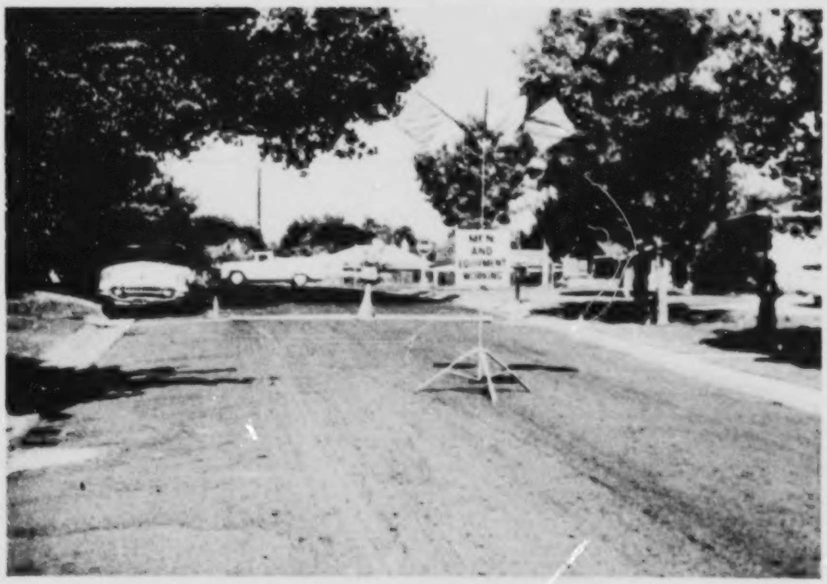

MEN
AND
EQUIPMENT
WORKING

Fig. 5.4. Traffic ramp protecting hose from traffic
(Courtesy of Sacramento County, Water Quality Division)

6. Hydrant gate valve.[4]

7. Air gap device (Figure 5.5).

Air gap devices are required to prevent any backflow of wastewater from a manhole into a drinking water supply. The purpose of an air gap device is to provide adequate space above the top of a manhole and the end of the hose from the fire hydrant so no wastewater will flow out the top of a manhole, reach the end of the hose from a fire hydrant, and be sucked back up the hose to the water supply. Suction conditions could develop if the water supply pipe near the fire hydrant should rupture and cause a washout or any other rare condition develop that could cause a backflow in the hose.

The tag line may vary from plain manila rope to synthetic rope or steel cable for the larger balls. Some synthetic ropes may be adversely affected by constituents in wastewater and break in many locations with no previous evidence of deterioration. Cables are considered more reliable.

The reel on which you store this tag line should hold at least 1,000 feet. The reason will be pointed out later. The reel should be portable and the rope easily uncoiled and recoiled.

When cleaning large lines, 14 to 48 inches, a power driven reel is needed and steel cable is used for the tag line. Usually the cable is 1/4-inch in diameter and is available with standard balling machines. Power bucket machines (Section 5.31, Bucket Machines) can easily serve this dual purpose.

Power driven reels are either truck mounted or trailer mounted with stabilizer legs to hold the machines firmly in place over the manhole while in operation. Because of the terrific strain and pressure generated as water builds up behind the ball, a strong steel cable is needed. Truck mounted winches are preferred by some agencies because this method allows the truck to tow other trailer mounted equipment, such as exhaust blowers.

The smaller balls are designed with diagonal ridges and grooves on the outer surface. As water builds up in the sewer in back of the ball, water will flow through these grooves and the ball will rotate.

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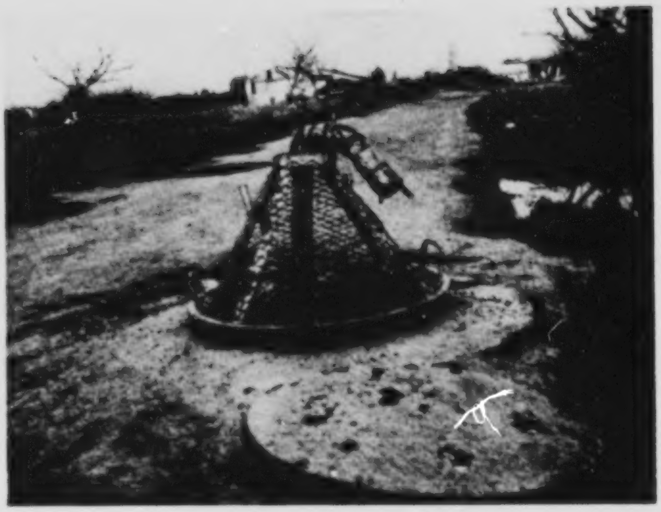
[4] WARNING. Use a hydrant gate valve to throttle flows from a fire hydrant. Never attempt to regulate flows from a fire hydrant using the hydrant's valve because water may flow out through the weep hole and undermine the hydrant.



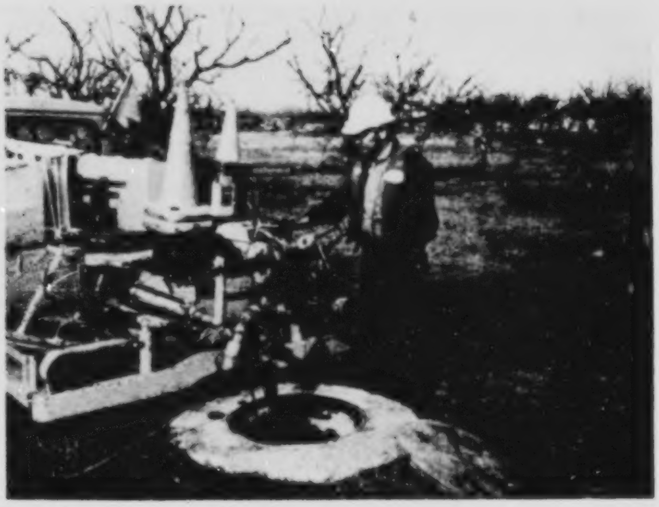


Fig. 5.5. Air gap devices
(Courtesy of Union Sanitary District)

The outside design of the large balls differ somewhat, usually having a heavy tread surface to encourage a scouring action to the interior of the sewer (Figure 5.6).

The ball is resistant to punctures and is inflatable by means of a valve core. Into each side of the ball a strong metal eye lug is molded to which a clevis and swivel (Figure 5.7, page 5-35) can be attached. The tag line is then attached to control the ball and to allow it to spin. This clevis and ball bearing swivel are very essential items since they keep the line from twisting. The clevis is quickly and easily fastened to the tag line and ball.

The reel, although primarily to hold the rope, also is used to apply a brake or drag to control the travel of the ball down the sewer.

The manhole guide jack or roller is essential to guide the tag line into the sewer without causing unnecessary wear and to give proper rolling action as the tag line is pulled back and forth or in restraining the ball.

Plugs, either mechanical or inflatable, are needed to control water coming into the working manhole from upstream. If there is insufficient flow in a sewer for balling, this method of "plugging off" the upstream water provides a method of getting an adequate supply of water to begin the balling procedure. Use a two-foot head of water on the ball which usually provides sufficient water velocity around a ball to clean a line. Plugs are not needed if the flow in the sewer is sufficient to develop the necessary head behind a ball.

If the material removed from the line is to be hauled away by the balling crew, a truck is needed. This truck can easily be the same vehicle used to carry the balling equipment to and from the job site.

QUESTIONS

5.21A What kinds of deposits in sewers can be removed by balling?

5.21B Why is balling commonly used in preventive maintenance programs?

5.21C How frequently should a sewer be balled in a preventive maintenance program?

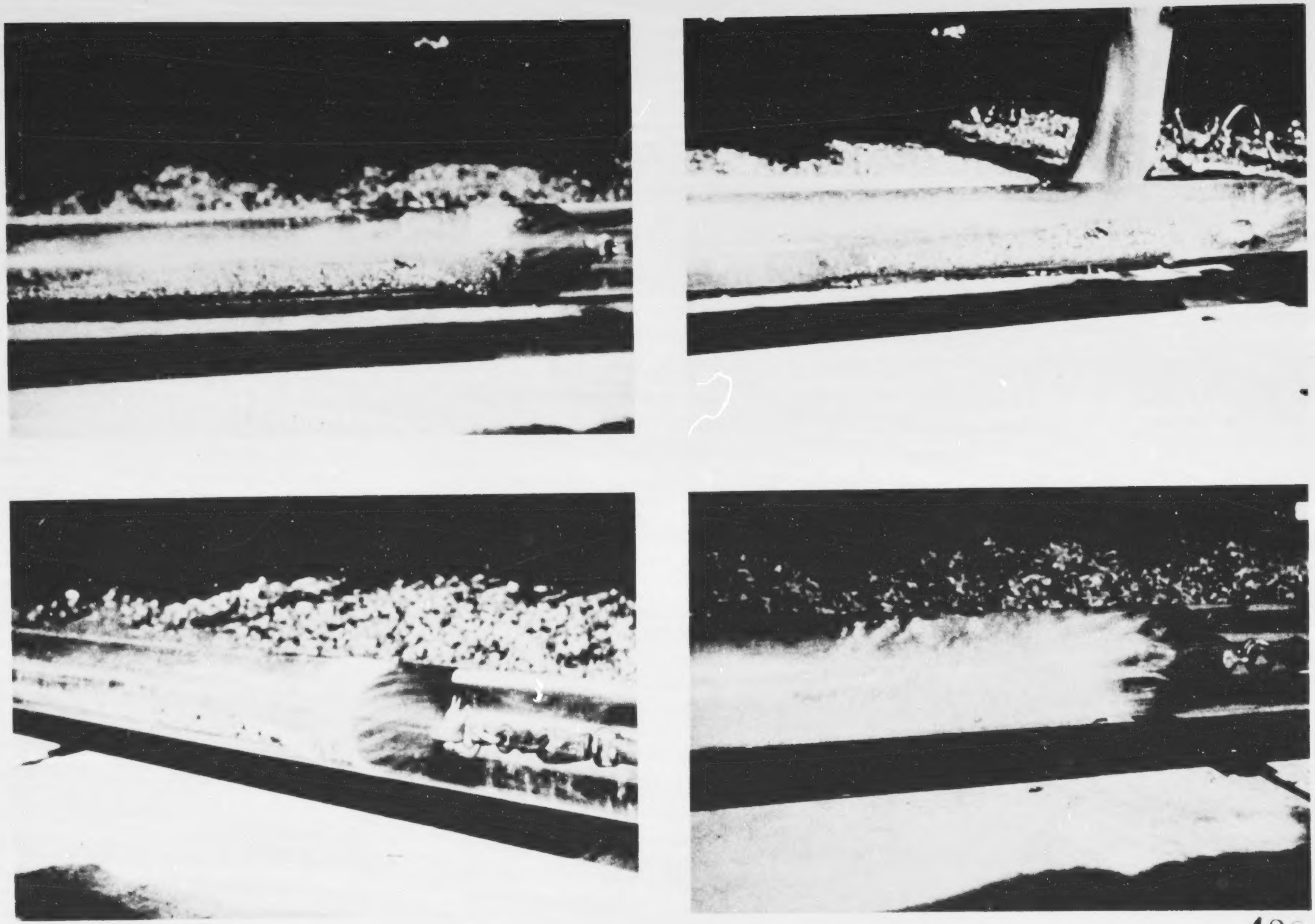


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Fig. 5.6. Scouring action cre[illegible]d by sewer ball

5.21D What is the minimum number of workers needed in a balling crew for cleaning lines up to 10 or 12 inches?

5.21E Where is the additional water obtained to provide the necessary head for a balling operation when flows in the sewer are low?

5.21F What is the purpose of the manhole guide jack or roller?

5.21G What is the purpose of an "air gap"?

5.212 Equipment Set Up

Procedures for equipment set up before cleaning sewers with a ball are outlined and discussed in the next two sections. Each worker on the crew must do the specified duties for the crew to be as efficient and productive as possible.

Before setting up the balling operation, certain safety measures need to be taken, both for handling street traffic and personal safety at and in the manholes (see Section 4.1, Traffic and Manhole Safety.) Now is a good time for a tailgate safety session(Section 9.82).

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14

Position the reel or power equipment so the tag line is centered in the upstream or working manhole (Figure 5.7 and 5.8). Attach the line to the ball using the clevis and swivel. Place the ball in the manhole by hand, unless the water is too high. If the water is high, push the ball into place with a forked rod. Insert the ball into the sewer just far enough to determine if it is inflated properly. The ball needs to be snug enough to cause good cleaning action (Figure 5.6), but not so tight the water cannot flow around the ball and carry it downstream. On the other hand, if it is too loose the ball only will float downstream with little cleaning action. When inflating the ball, be careful that it does not become too hard. The ball must be soft enough so it can squeeze around obstructions in the sewer.

Most sewer balls have two nipples on opposite sides that are used to attach the line to the ball. If one nipple breaks, use the other nipple. Do not attach a line to one nipple from the upstream manhole and a line to the other nipple from the downstream manhole, because this will cause a reduction in the swirling action of the ball and thus reduce the cleaning action.

The manhole guide jack or roller is now installed in the bottom of the manhole and secured to allow the tag line to run freely and away from areas of the manhole that will cause abrasion. This roller or jack must be secure enough to allow strain on the tag line without lifting the jack out of position.

A worker is stationed at the downstream manhole with adequate communication with the worker running the ball and tag line at the upper manhole. The downstream worker's job is to keep the worker operating the ball informed of conditions in the downstream manhole during the balling operation.

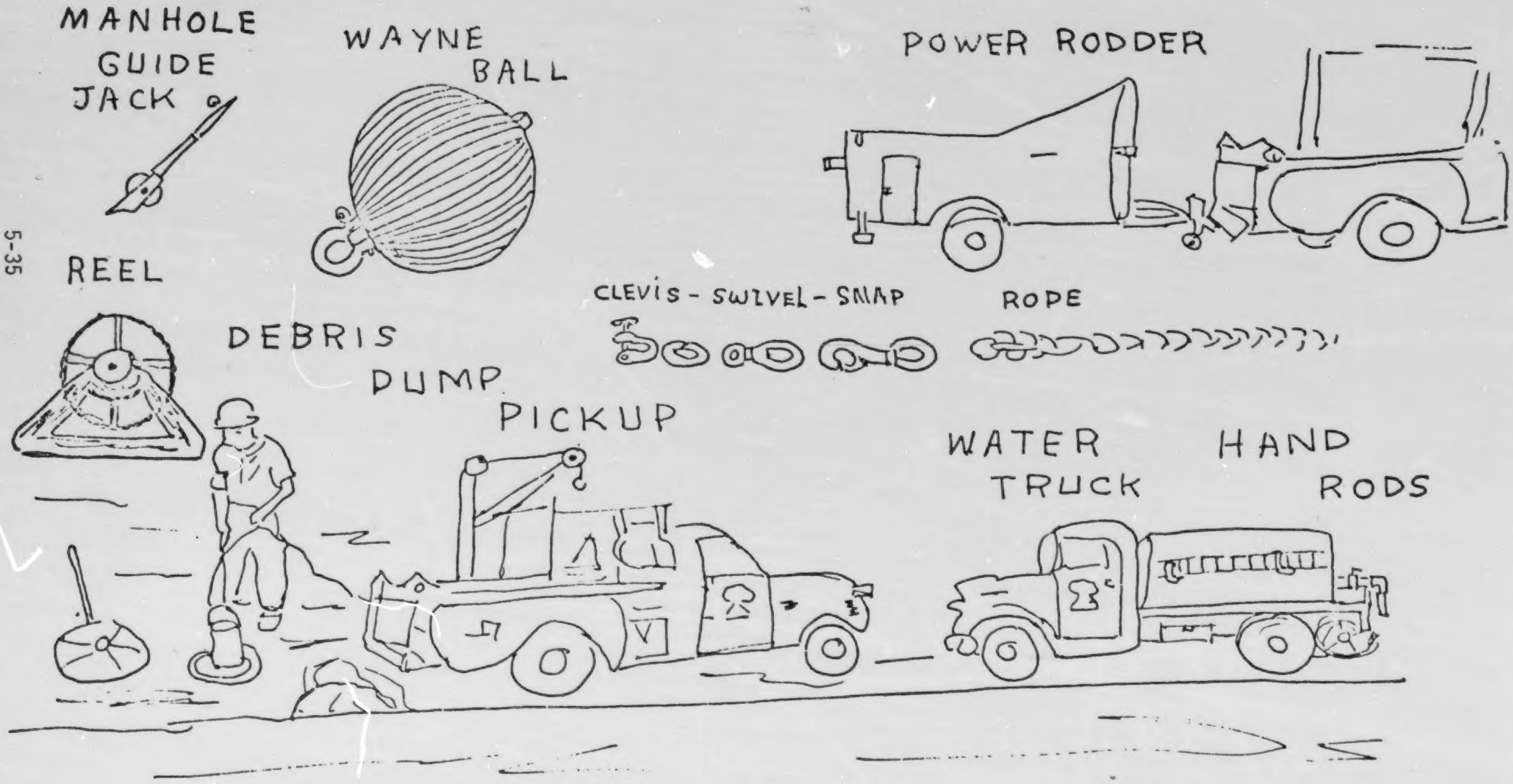

MANHOLE GUIDE JACK
WAYNE BALL
POWER RODDER
REEL
CLEVIS - SWIVEL - SNAP
ROPE
DEBRIS
DUMP
PICKUP
WATER TRUCK
HAND RODS

Fig. 5.7. Balling equipment

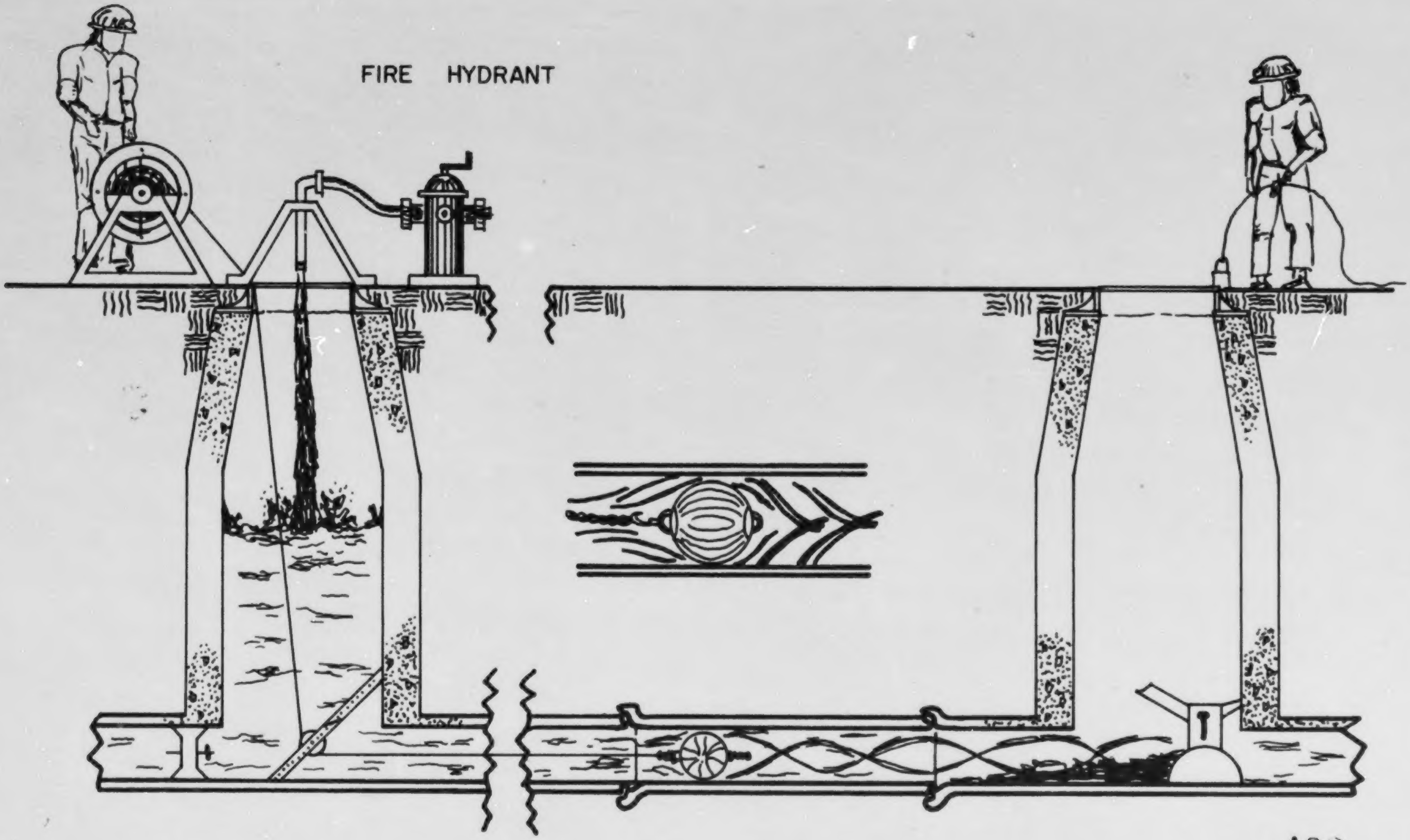

FIRE HYDRANT

Fig. 5.8. Balling operation

5.213 Cleaning Operation

The balling operation is now ready to begin. If the water supply coming into the working manhole is not enough to give proper head pressure, the plugs can be used. Insert plugs into lines coming into the manhole so the section of pipe being cleaned is isolated. Discharge water into upstream manhole with the water truck or from a fire hydrant with an air gap over the manhole (Figure 5.5). Usually a balling operation will function very well with 2.0 feet of head in the upstream manhole to create a scouring velocity around the ball. There should be a maximum elevation set by the crew leader that the water head may reach. If plugs are used to store water in the upstream line for release to operate the ball, be sure to attach a safety line securely to them. When the plug is released, the water pressure behind it will have a tendency to "blow" it out and there is the danger of losing it into the downstream line and causing a major problem. Either method will create enough pressure to operate the ball properly.

As the ball begins to travel downstream, it will also be turning with water traveling around it and flushing debris ahead of it. Hold the tag line tight and allow the ball to travel slowly downstream at a steady rate (Maintenance Equipment Operator). This procedure produces the best cleaning action. Ineffective cleaning results if the ball travels too fast. If you are short of head pressure, holding or stopping the ball travel and then releasing it at intervals will increase the head pressure and spinning action. This also causes the jet stream around and in front of the ball to break up debris deposits. The ridges of the grooves in the ball's surface also will give a scouring action to the interior of the sewer.

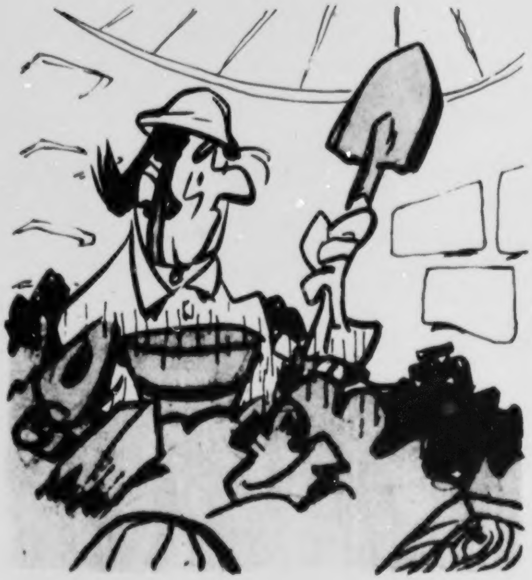
If the ball suddenly stops, this is an indication of a large deposit, that sufficient material has built up to stop the ball travel, the ball has hit a bad tap, or a crushed or offset pipe. By pulling back on the tag line a short distance, the ball will "eggshape" causing first, a vacuum in front of it and then a sudden flushing action. This "bouncing" of the ball sometimes has to be repeated several times to remove large or stubborn deposits. If a deposit can't be removed or reoccurs frequently, complete a form requesting that the line be televised.

As the operation continues, the debris to be removed will start appearing when the ball gets within 20 to 25 feet of the downstream manhole. When the debris does begin to appear, a worker should be in the downstream manhole with a short handled shovel, shaped to fit the channel, so that the worker can remove the debris as it appears. The accumulation of the debris may be slowed down by holding the tag line and stopping the forward progress of the ball. By releasing the ball a little at a time, the worker in the downstream manhole is able to remove all of the debris as it appears. Do not use a sand trap or otherwise retard the flow in the downstream manhole because a trap can hinder the effectiveness of the balling operation.

When balling a sewer that contains considerable debris and slimes that are producing hydrogen sulfide (rotten egg smell), it may be desirable to use a sand trap. This is better than having a worker in the manhole shoveling debris and being exposed to the hydrogen sulfide which is being pushed down the sewer ahead of the balling operation. If a sand trap must be used (as shown in Figure 5.8), the pressure head behind the ball will have to be raised to maintain the cleansing velocity around the ball.

Constant communication between the reel worker (Maintenance Equipment Operator) and the worker removing material from the bottom of the downstream manhole (Maintenance Man I) relayed through the worker above the downstream manhole is essential for the safety of the worker in the downstream manhole.

If auxiliary water is being used, shut this water off at the control valve once debris starts arriving in the downstream manhole. The downstream workers should shovel this material into a bucket and lift the bucket from the manhole with a rope as quickly as possible so the operation can continue.



Continue balling and watch and listen for the ball at the downstream manhole. Keep it from entering the manhole until all remaining material has been removed. A strong shovel or bar can be placed over or across the incoming line to

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hold the ball back. When the manhole is clean, the ball can enter the manhole. If the tag line is of sufficient length to reach the next downstream manhole, insert the ball in the downstream line, and the operation can continue without another complete set up. The one crew needs only to move to the next lower manhole and get ready to remove debris when it starts arriving.

When the operation is completed, disconnect the ball and rewind the tag line on the storage reel. If using a cable, attach a weight to the end of the cable to prevent twisting. With the removal of the plugs and lower guide roller, you are ready to move on downstream. The debris should be loaded on the truck and disposed of at a disposal site. The manhole cover rings should be cleaned and the covers replaced and inspected for proper seating. Clean the street.

Communications between crew members can be improved with the use of sound powered telephones or effective hand signals. The next two pages illustrate hand signals used by crews cleaning sewers.

QUESTIONS

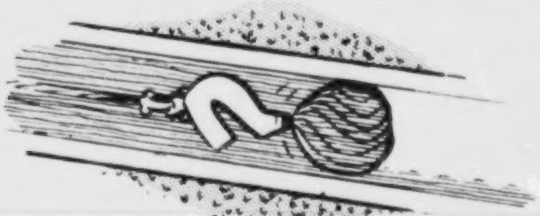
5.21H Why must a sewer ball be properly inflated?

5.21I How is the material cleaned from the sewer by the ball removed from the collection system?

5.21J How should the ball move downstream?

5.21K What could cause a ball to stop moving downstream?

5.21L How could you determine what caused a ball to stop moving downstream?



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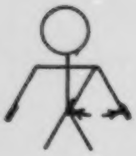
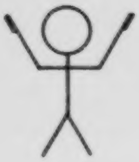
HAND SIGNALS IN SEWER CLEANING

1


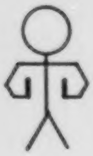
ALLOW BALL TO TRAVEL OR TO MOVE

ARM IS SWUNG IN FRONT OR SIDE OF BODY WITH FINGERS EXTENDED

2


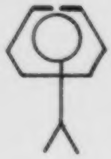
STOP OR HOLD

ARMS ARE HELD UP OUTSTRETCHED

3


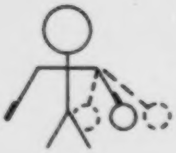
ALLOW BALL TO TRAVEL A SHORT DISTANCE

PRECEDED BY TRAVEL SIGNAL - BOTH HANDS ARE HELD APART PALMS INDICATING DISTANCE FROM 2 FEET TO 10 FEET OUTSTRETCHED.

4


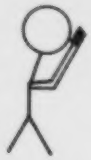
BALL HAS ARRIVED - GIVE LINE SLACK

ARMS ARE HELD UP AND OVERHEAD WITH FINGERTIPS TOUCHING.

5


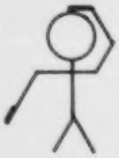
BALL IS OFF SNAP REEL IN TAG LINE

HOLD SEWER BALL TO SIDE OF BODY AND SWING.

6


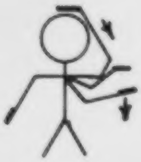
BALL IS DEAD - PROBABLY PLUGGED MAIN

HAND OR HANDS HELD AT SIDE OF TILTED HEAD (as in sleeping)

7


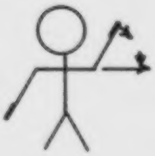
MANHOLE IS SURCHARGED OR HAS HEAD OF WATER

HAND IS HELD FLAT TOUCHING TOP OF HEAD

8


SURCHARGED OR WATER HEAD DECREASING

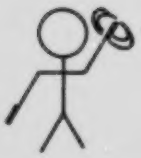
PRECEDED BY HEAD SIGNAL - MOVE HAND AND ARM SLOWLY DOWN.

9


UPSTREAM OR DOWNSTREAM DIRECTION

PRECEDED BY TRAVEL SIGNAL - MOVE HAND AND ARM UP ABOVE HEAD AND THEN DOWN POINTING IN DIRECTION OF TRAVEL.

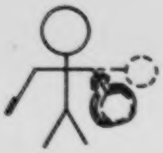
10



TURN ON FULL HYDRANT WATER SUPPLY

ONE ARM HELD OVER HEAD IN CIRCULAR MOTION.

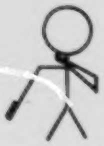
11



TURN ON HYDRANT WATER SUPPLY

ONE ARM IS HELD OUT TO SIDE AND MOVED IN CIRCULAR MOTION (Low for little water - high for more water)

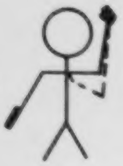
12



TURN OFF HYDRANT WATER SUPPLY

ONE ARM IS BENT SHOULDER HIGH WITH FINGER TIP MOTION CUTTING ACROSS THROAT.

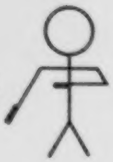
13



DISTANCE - 100 FEET

CLOSED FIST WITH ARM BROUGHT UP TO ABOVE HEAD. (Each raise of fist means 100 feet)

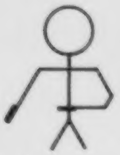
14



DISTANCE - 75 FEET

HAND HELD CHEST HIGH WITH PALM DOWN

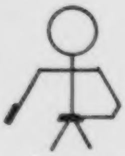
15



DISTANCE - 50 FEET

HAND HELD WAIST HIGH WITH PALM DOWN

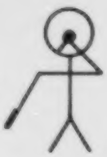
16



DISTANCE - 25 FEET

HAND HELD KNEE HIGH WITH PALM DOWN

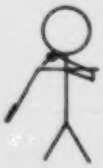
17



HIGH PRESSURE MACHINE - INCREASE WATER PRESSURE

WITH MOUTH OPEN - THUMB MOTION TO MOUTH

18



HIGH PRESSURE MACHINE - DECREASE OR CUT WATER PRESSURE

THUMB MOTION ACROSS THROAT

5.214 Precautions and Safety

Certain precautions have to be taken or at least considered before and during all cleaning operations.

Using water pressure in the cleaning of gravity flow sewers always requires care and judgement with respect to basement fixtures and low elevation homes.

If there is any possibility of the water level behind the ball getting higher than basement fixtures (Figure 5.9), inspect these residences or business establishments for potential problems or use another method of cleaning, such as a high velocity cleaner.

If a stoppage occurs below the ball, it must be cleared as soon as possible to avoid flooding homes or streets. First try to break the stoppage by using the ball. If this doesn't work, use a hand rod, power rodder, or high velocity cleaner at the downstream manhole to clear the stoppage.

As previously outlined, all street work requires safety measures sufficient for the particular conditions involved. Emphasis should be made in getting barricades or warning measures a good distance away from the working areas. Always use flagmen where there is a need to control traffic (see Section 4.1, Traffic and Manhole Safety).

If a sewer ball becomes stuck, try to work it loose without breaking the cable. A high velocity cleaner (Section 5.22) inserted in the downstream manhole hole may be able to go up the line and knock the ball loose. Another approach is to use a power rodder and try to puncture the ball. When a ball becomes stuck, be sure upstream homes don't flood while you are working the ball loose.

5.215 Records

See Section 5.18, Records.

5.216 Summary

The balling method of cleaning is a relatively easy procedure, is very effective, and uses a minimum amount of equipment. Common sense measures of operations are involved and techniques can be developed and used to overcome problems common to this method of cleaning.

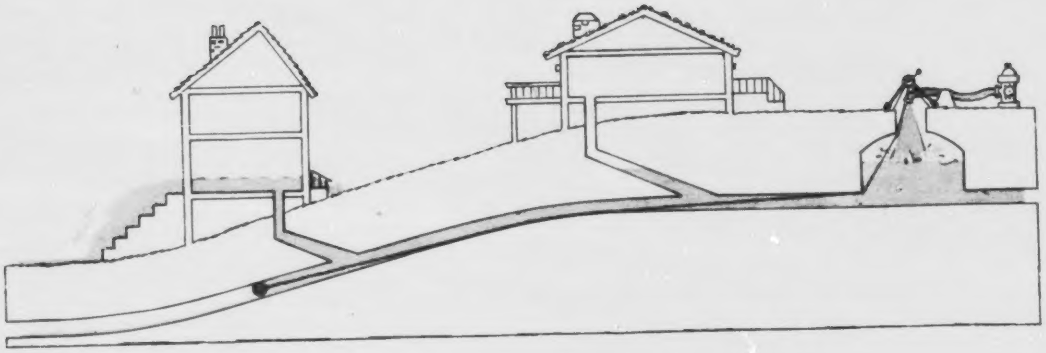


Fig. 5.9. How to flood a basement

439

QUESTIONS

5.21M What would you do if a stoppage occurred below the ball?

5.21N What safety precautions should be taken during a balling operation?

5.22 High Velocity Cleaning Machines

The use of water pressure to clean sewers dates back to the early 1900's; however, this method has been improved upon with the present day high velocity cleaning machines.

The fundamental idea of using a self-propelling nozzle on the end of a hose is still used. Instead of using a fire hose hooked to a hydrant, we have self-contained portable equipment, hoses and nozzles that not only do a better job, but do it faster and cheaper.

High velocity cleaning machines are used to:

1. Open stoppages
2. Remove grease
3. Clean lines of debris
4. Wash manholes and wet wells

Although the design of the high velocity cleaning machine will vary with different manufacturers, they are essentially all the same.

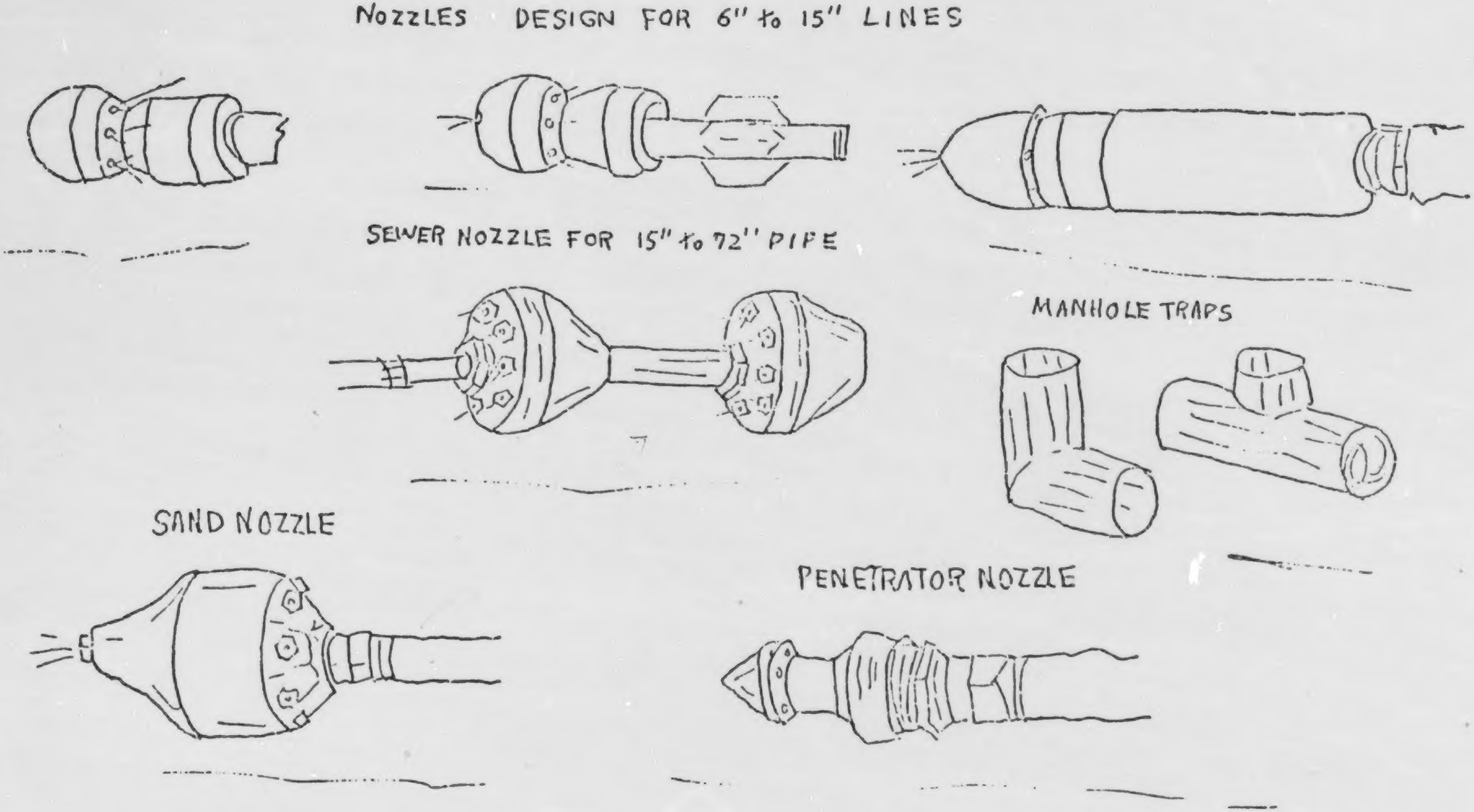
5.221 Equipment and Manpower

These machines consist of a water supply tank usually with a capacity of 1,000 gallons or more, a high pressure water pump and an auxiliary engine for its operation (Figures 5.10, 5.11 and 5.12). The unit will have a powered drum reel capable of holding at least 500 feet of hose, usually one-inch ID. To the end of this hose, a nozzle will be attached which will create water velocities that do the cleaning. Accessories are varied and new tools continue to be developed as well as techniques in their use. Among these accessories for this cleaning method will be a nozzle with rear jets only, a nozzle with rear jets and one forward jet, a dual nozzle, a hose roller or hose guide, and a wash-down gun or nozzle. In addition, sand or debris traps, manhole shovel, debris bucket and hand line, and a manhole lifter are essential tools too.

For purposes of discussion, we will consider the use of a truck-mounted, high velocity cleaning machine. These units are available as trailer mounted types as well, but they usually have less water tank capacity.

We will concentrate on the cleaning of sewers with 6 to 15-inch diameters; however, because of the design of this equipment, it is also effectively used for street cleaning, back-up fire control equipment, chemical spraying, and watering landscaping along streets and in parks (Figure 5.12).

The machine is operated by one worker (Maintenance Equipment Operator). This worker will need help in order to be notified when the cleaning nozzle has reached the upstream manhole, and when the grit and debris are removed from the working manhole. Safety regulations require two workers topside when a worker is in a manhole.



NOZZLES DESIGN FOR 6" to 15" LINES

SEWER NOZZLE FOR 15" to 72" PIPE

MANHOLE TRAPS

SAND NOZZLE

PENETRATOR NOZZLE

Fig. 5.10. High velocity cleaning equipment

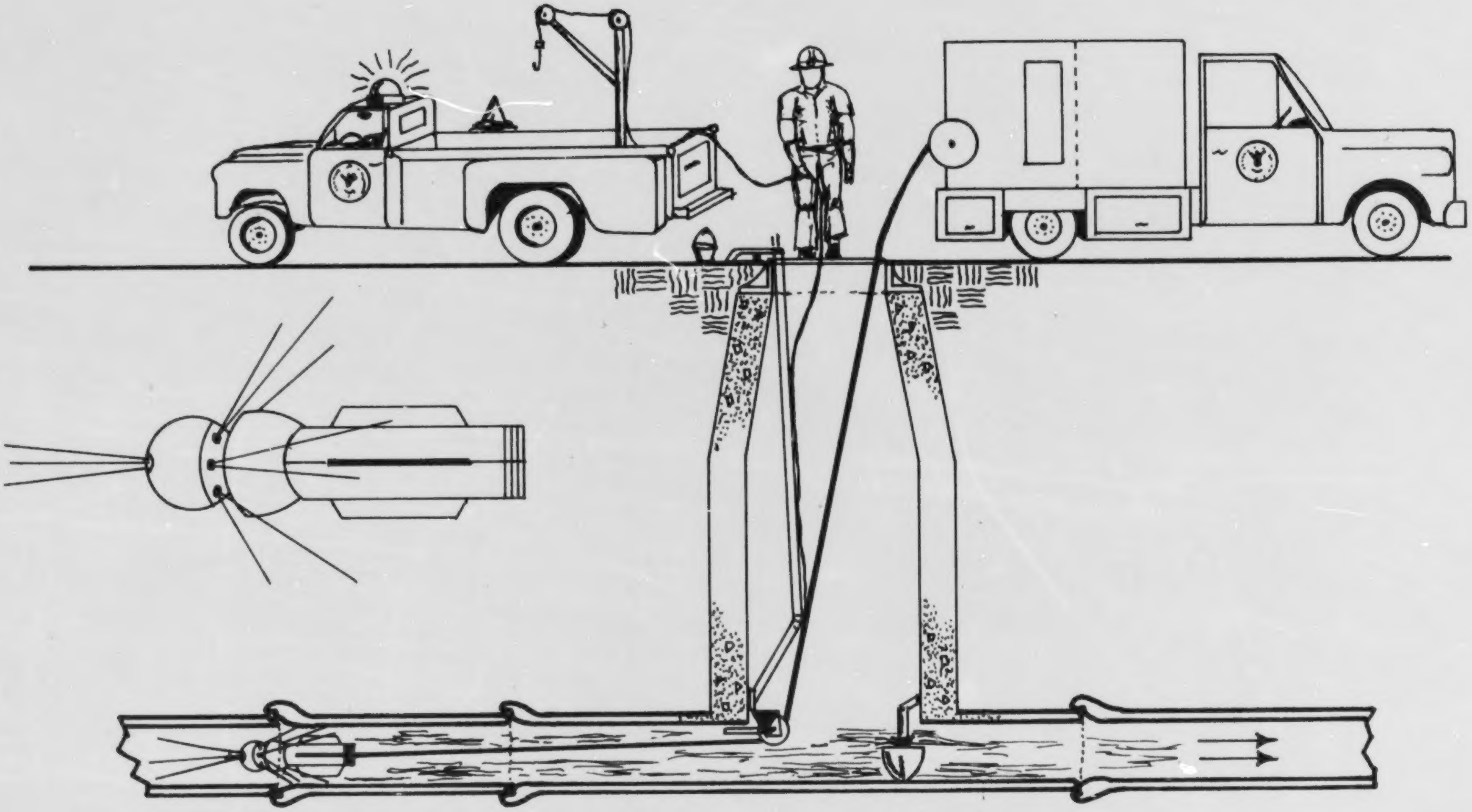


Fig. 5.11. High velocity cleaning operation

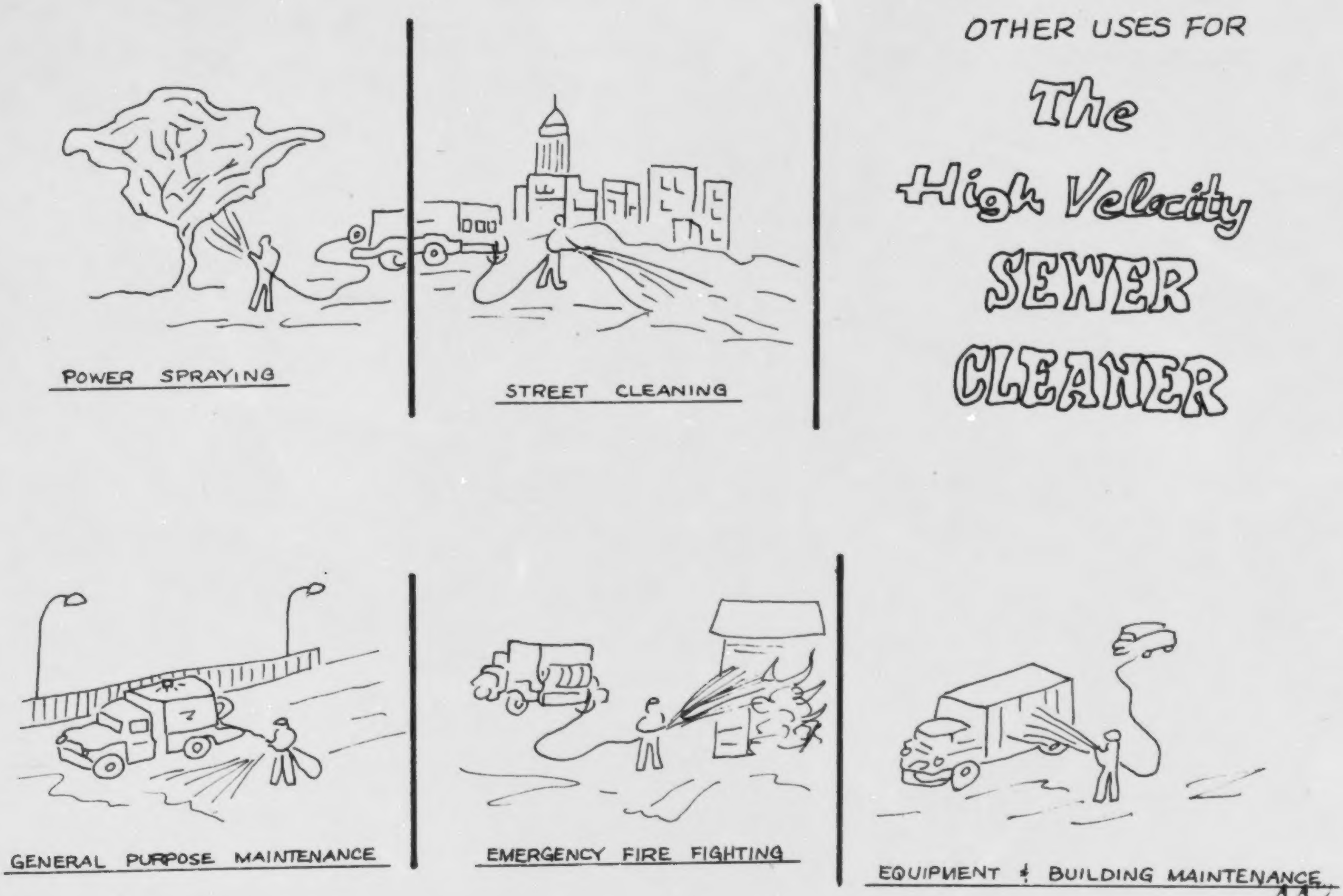

OTHER USES FOR
The
High Velocity
SEWER
CLEANER
POWER SPRAYING
STREET CLEANING
GENERAL PURPOSE MAINTENANCE
EMERGENCY FIRE FIGHTING
EQUIPMENT & BUILDING MAINTENANCE

Fig. 5.12. Uses of high[illegible]locity cleaner

A foreman can be called to assist a two-worker crew whenever someone must enter a manhole or other confined space. Additional assistance may be needed for traffic control. Manpower requirements include:

1. Maintenance Equipment Operator
2. Maintenance Man I (one or two people)

QUESTIONS

5.22A What are the uses of high velocity cleaning machines?

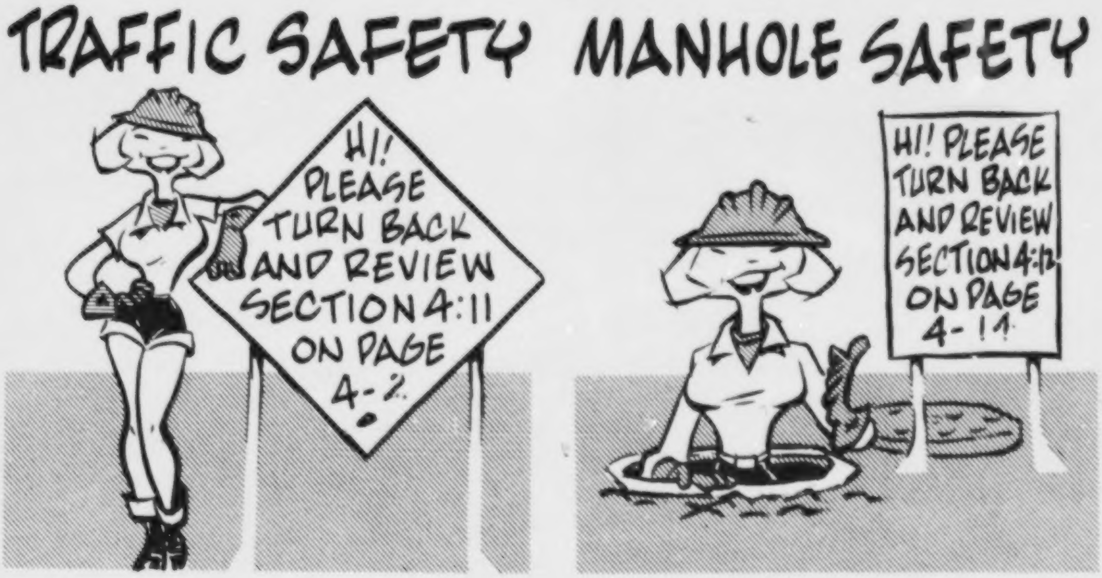
5.22B How do high velocity cleaners clear sewers?

5.22C How many people are required to operate a high velocity cleaning machine?

5.222 Equipment Set Up

Because this piece of equipment is a self-contained mobile unit and this method of cleaning smaller sewers is relatively fast, several set ups will usually be made in the course of a day's work.

Basic safety measures still apply, since for the most part this equipment will be set up in the street and traffic conditions must be considered. See Section 4.1, Traffic and Manhole Safety, for safe procedures.


TRAFFIC SAFETY
MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2.
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-11

Fill the water tank from a fire hydrant close to the area where you will do the cleaning. A 1,000-gallon tank full of water weighs 8,340 pounds plus the weight of the tank and truck. Even with baffles in the tank, sharp turns or quick stops can create driving hazards.

When using a fire hydrant, attach a gate valve on the discharge line to regulate flows. NEVER throttle or control flow from a fire hydrant with the hydrant valve because this could damage the hydrant valve. When filling a water truck, you must have an air gap between the discharge line and the top of the water tank.

The machine will be equipped with a length of fire hose and an approved hydrant wrench. If the amount of water used is to be recorded, an approved meter also will be part of the equipment.

If a given area or subdivision is to be done completely, start at the top or highest point in the collection system. Whether routine cleaning or spot cleaning, position the high velocity cleaner hose reel over the center of the downstream manhole.

Select the nozzle to be used for this size line. The angle of the rear jets vary from 15 to 30 degrees. Usually, the smaller the pipe, the less angle needed. Experience will teach the operator the right tool and technique. Test the manhole atmosphere for sewer gas (see Section 4.1, Traffic and Manhole Safety). Install the proper size sand or debris trap in the downstream manhole. Start the auxiliary engine; turn the reel directional control to "out"; and using the reel speed control, lower the hose and cleaning nozzle into the manhole. Direct the nozzle upstream in the line leaving a sag in the hose. The hose guide or roller is usually put into place after the hose has started up the line. The hose needs freedom at this point since the water pressure that forces water at a high velocity out of the rear orifices gives the jet propulsion action that moves the nozzle up the line. The hose guide should not obstruct this first start of the operation. The cleaning operation should be ready to begin.

QUESTIONS

5.22D When a high velocity cleaning unit is set up in a street, what measures should be taken to warn traffic?

5.22E Why should the water tank be filled close to the working area?

5.22F Where should you start to clean a given area of a subdivision?

5.22G Which direction does the nozzle go in the sewer?

5.223 Cleaning Operation

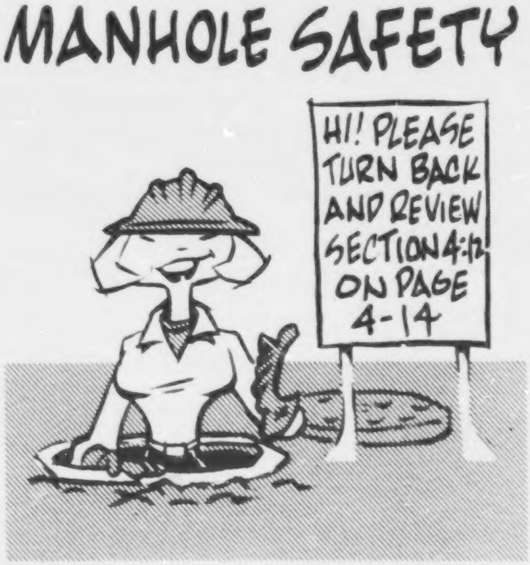
Turn the water valve on and start the high pressure pump. Water now is being pumped through the hose and cleaning nozzle. With an increase in pump speed, sufficient water velocity will build up to propel the nozzle up the sewer.

An experienced operator is the best person to teach you how far to go into the sewer. Often it is possible to go several hundred feet, but it is not always safe to do so unless a history of this part of the collection system is known. First try 50 feet to check the situation in the sewer (Maintenance Equipment Operator). In any case, if the hose suddenly slows or stops, don't try to go farther. By increasing pressure you may be able to go farther, but don't do it before determining how much material is in the line.

At this point, with the hose roller in place, turn the reel directional control to "in" to return the nozzle. Increase engine speed to obtain approximately 1,000 PSI or the proper rating of the particular unit.

With the reel speed control, slowly start the hose reeling in until the nozzle is just ready to come back into the manhole. The amount of material you have brought back will determine how far and how fast subsequent runs can be made. Repeat this operation until the upper manhole has been reached and no further material is brought back.

During this operation several items may have to be considered and done. If this is a normal operation of routine cleaning, perhaps the entire line from manhole to manhole can be cleaned without enough material building up in the working manhole to make removal necessary until the job is finished. On the other hand, it may be necessary to clean out the channel after each "pull" if there is a lot of debris in the line. When loosened materials build up to the point of overflowing the debris trap, pull the hose and nozzle out of the manhole. Stop the pump until after the debris is cleared.


MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4.12 ON PAGE 4-14

Retest the manhole atmosphere for sewer gases to be sure the ventilation procedures are effective. If excessive odorous or hazardous gases are present, a self-contained breathing apparatus may be necessary in addition to ventilation. Have two workers standing by topside. Allow a worker properly equipped with a safety harness to enter the manhole and shovel the debris into a bucket (Maintenance Man I) which in turn is pulled to the surface with a hand line (Maintenance Man I).

During the cleaning operation, care has to be taken to keep the nozzle moving and pump operating at all times. This is especially true in small lines since you do not want to cause a stoppage. A stoppage can occur if you try to go into the line too far at a time and bring back so much material that the nozzle cannot move it downstream fast enough. The smaller lines then quickly fill with water and this in turn goes up the building service lines. If this happens on shallow lines, home damage may result from flooding. Always watch the flow coming into the working manhole. If this flow should stop, a stoppage has developed in the sewer. Pull the hose and nozzle out at once and start over. If the nozzle hits an obstruction and stops, pull the nozzle back to clear the line and then run the nozzle into the obstruction again.

The exact distance the cleaning nozzle has moved up in the sewer must be known at all times. Most machines are equipped with a footage meter; but if not, have some identification - a hose coupling or so many wraps of hose, so as to give an estimate of where you are in the sewer. If you know the distance between manholes, the footage counter will allow you to make the final run without someone (Maintenance Man I) being at the upper manhole.

The high velocity cleaning machine also may be used for stoppages in sewers. Set up is the same as routine cleaning. A nozzle with a forward jet as well as rear jets may be used. This forward jet provides a cutting action ahead of the nozzle. Also the debris trap would be replaced perhaps with a special fork or pole to allow the free flow of wastewater when the stoppage is broken. Large pieces of solids are caught without causing the working manhole to back up.

Upon contact with the stoppage, if the nozzle will not penetrate the stoppage, pull the hose back a few feet by hand and let go. The nozzle will shoot forward quickly and give a pounding effect on the stoppage. When it breaks loose, retrieve the hose and nozzle quickly. After the line returns to normal, reclean the line completely. Inspect the upstream manhole and flush with the wash-down hose and wash the street free of any overflowed wastewater and solids, disinfect and complete whatever cleanup is needed. Disinfection can be accomplished by the use of a hypochlorite solution.

The high velocity cleaning machine is quite effective in cleaning inverted syphons and easement areas. Special rollers are available where the truck cannot be positioned over the manhole. Remote control equipment is available if practical.

QUESTIONS

5.22H How often should the nozzle go up the sewer and be brought back to the downstream manhole?

5.22I What is done when the loosened materials build up and overflow the debris trap?

5.22J Why must the nozzle be kept moving at all times?

5.22K What should be done if flow stops in the working manhole?

5.22L How are high velocity cleaning machines used to clear stoppages?

5.224 Precautions and Safety

Although some of the precautions of operation have been given, there are others which soon become obvious. One of these is cleaning from a manhole to a cleanout. Most often the cleaning nozzle will stop at the bottom of the cleanout. On short runs, however, it is possible to have enough speed and thrust that the nozzle will go up to the street surface and even knock small cleanout covers out of place. When cleaning up to a cleanout, there is also the chance of getting the nozzle stuck. If this should occur, shut the machine off, pull the cleanout cover and dislodge the nozzle with a long rod or pole.

While cleaning, so much material can build up below the nozzle that you cannot pull the nozzle through under pressure. Stop the pressure and pull the nozzle back through the stoppage "dead" (without water flowing out the nozzle). If this fails, try to get the nozzle to the upstream manhole and take it off, thus allowing only the hose to be pulled back through the stoppage to the downstream manhole. Replace the nozzle and go back up the line after the stoppage.

Often a bend in the line will prevent you from pulling the nozzle back under full pressure. The more pressure at the nozzle, the stiffer the hose becomes. Reduce the pressure or even turn it off for a short distance until you are past the bend.

In cold weather, particular precaution has to be taken to keep the equipment from freezing. Special attention should be given to the high-pressure pump to make sure that it is properly drained. If the machine is equipped with a canopy over the engine and pump area, the areas can be separated by a curtain and a small electric heater can be left inside the pump area overnight or when not in use during freezing weather. Another approach to prevent freezing during cold weather is to install a piping system which allows water to circulate through the pump and hose. Be sure to include the hose because some water always remains in the hose, no matter how much time and care are taken to drain the hose.

Do not allow an inexperienced worker to operate the machine alone. Personal safety is not so much a problem because of the design of the machine; however, costly problems can develop if care is not given to existing conditions in the collection system and those that the cleaning operation can create. Caution and experience are required to prevent "blowing toilets" with a high velocity cleaner.

Also, do not sacrifice clean lines for footage. This equipment is capable of doing a thorough job of cleaning. There is the tendency to consider the line to be clean when perhaps you are running low on water. Take the time to get another load and make sure the line is properly cleaned.

5.225 Records

See Section 5.18, Records.

QUESTIONS

5.22M What precautions should be taken when cleaning from a manhole to a cleanout?

5.22N What would you do if so much material built up that the nozzle could not be pulled back to the downstream manhole?

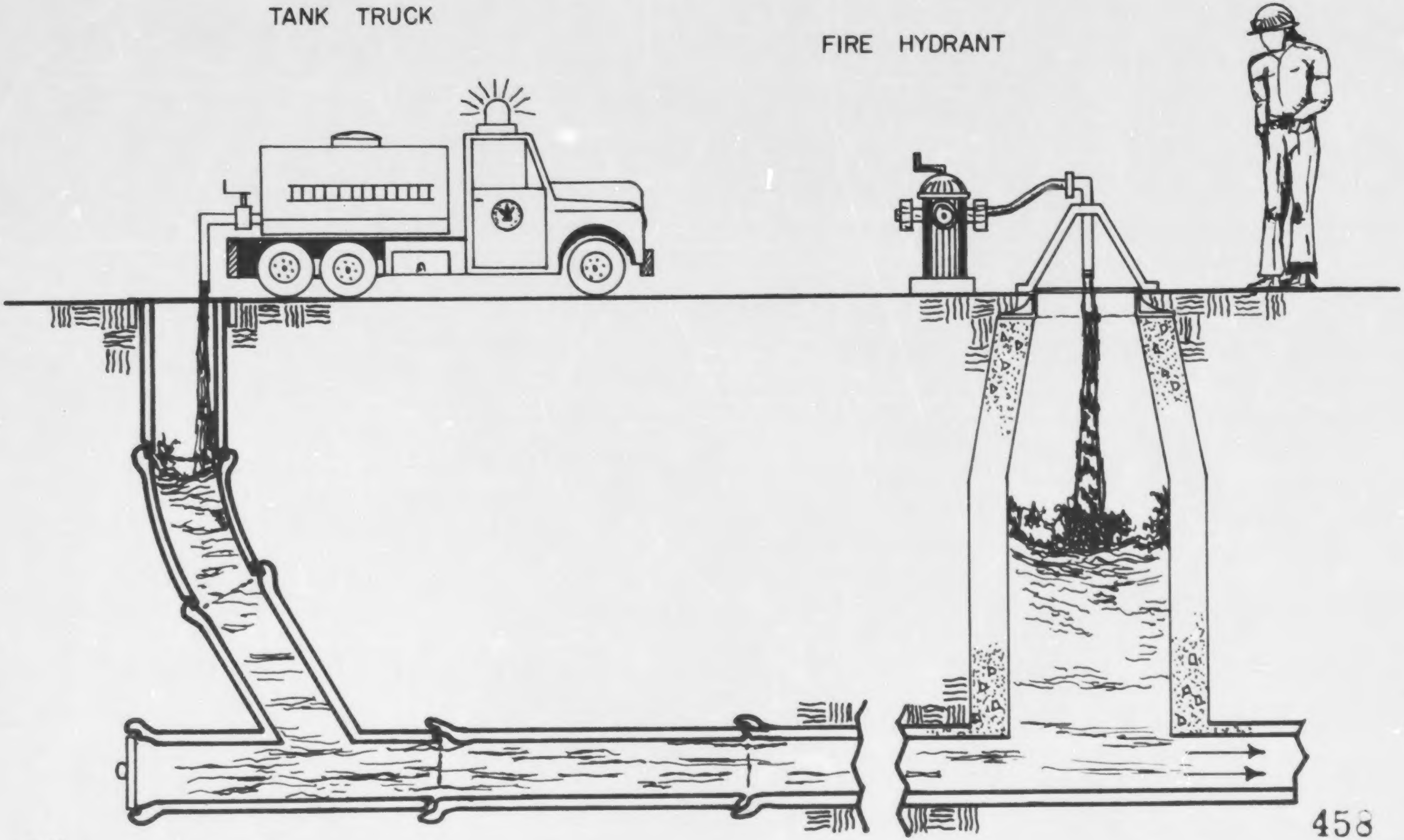
5.22O What precautions must be taken during cold weather?

5.23 Flushing

Flushing (Figure 5.13) is another method of hydraulic cleaning and is occasionally used at the beginning of the collection system where low or sluggish flows permit the deposition of solids. This procedure may be effective in removing floatables, but not grit and other heavy solids. Flushing also is used with mechanical clearing operations such as power rodders and bucket machines. High velocity cleaners and balling do a much better job of cleaning sewers than flushing.

During the flushing operation, observe the flow characteristics in the sewer - is the flow through the manhole slow or sluggish? A partial stoppage may restrict the flow of the flushing water being discharged into the sewer. Observations of lower than expected flows at a downstream manhole thus indicate that the upstream segment of the line requires additional cleaning. As the water flows, a physical and visual check can be made of the material in the line such as sand, grease, and debris. This observation also may dictate that more extensive cleaning is needed.

Stoppages are commonly located during the flushing operation. Material often will have built up to the point of causing a stoppage when just a sudden charge of water will break it loose, thus clearing the line. Having this large amount of water passing through all at once has a definite control on rodents and insects.


TANK TRUCK
FIRE HYDRANT

457

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Fig. 5.13. Flushing operation

Also cleaning the manholes with water pressure eliminates manhole shelf build up of street dirt and debris. Cleaning the manhole with water pressure, combined with the flushing action within the sewer, will minimize the build up of sulfide and slime in the line. This is one of the primary problems of line decay and replacement. Flushing may be used in steep hills where the use of balling or high velocity cleaners creates a high risk of flooding homes when not properly operated.

This method of cleaning in smaller collection systems usually must be repeated frequently to prevent many routine problems, but requires large volumes of water. Before starting a flushing operation, notify the water department whose hydrants will be used as a source of water. The opening and closing of hydrants must be done with great care because improper procedures could create water quality problems in the water distribution system.

5.231 Manpower and Equipment

Because of the small amount of equipment and workers involved in flushing, the actual cost appears attractive. However, the procedure may not be cost effective because of the limited cleansing action from flushing.

A tank truck with a capacity of 1,500 to 2,000 gallons is needed. The truck should be equipped with a reel for holding approximately 100 feet of 1-inch ID hose and a pump to give sufficient pressure to do an effective job of manhole cleaning. The nozzle type may vary from an adjustable model to a plain piece of pipe reduced to give a good cutting action. A 1/4-inch pipe nipple brazed onto a 1-inch female hose fitting provides a good stream (if the pump provides 25 to 30 psi in the line) for hosing down the manhole barrels and a shelf prior to flushing the line.

A 2-1/2-inch or larger gravity discharge line from the bottom of the tank on the truck should be provided to permit a large flow of water. Location of the line must be convenient for the truck driver to position it over the manhole. If possible, the ideal location is just ahead of the left front wheel. This line should be equipped with a quick opening, full flowing valve. A short piece of old inner tube fastened just above street level will help direct the flow of water into the manhole if positioning is difficult.

The tank truck equipment should include a good filler hose, usually a short length of fire hose to reach from a fire hydrant to the top of the tank's filling hatch, hydrant wrench, water meter, air gap device, and manhole lifter. Some communities require a 2-1/2-inch water meter so that they can pay for the water used for flushing.

A debris bucket, rope and manhole shovel are other pieces of essential equipment, plus the usual safety equipment (Chapter 4, Section 4.1, Traffic and Manhole Safety). The equipment and tools for this operation should be arranged on the tank truck in such a manner as to be handy and within the limits of space available.

Two workers are needed and they should be clothed with hard hats, red vests, and gloves. Typical street traffic should be expected but keep in mind too, you probably will not be long at one manhole. Manpower requirements are:

1 Maintenance Man I

1 Maintenance Man II

If the flushing crew consists of only two workers, neither one should ever be allowed to enter a manhole. Flushing crews usually have to enter every third or fourth manhole to remove debris. Whenever a worker enters a manhole for any reason, two workers must be topside at all times. The third worker could be a Maintenance Man II or another worker that could be readily available when needed.

QUESTIONS

5.23A Where in the collection system is flushing commonly used to clean lines?

5.23B What does lower than expected flows at a downstream manhole indicate during a flushing operation?

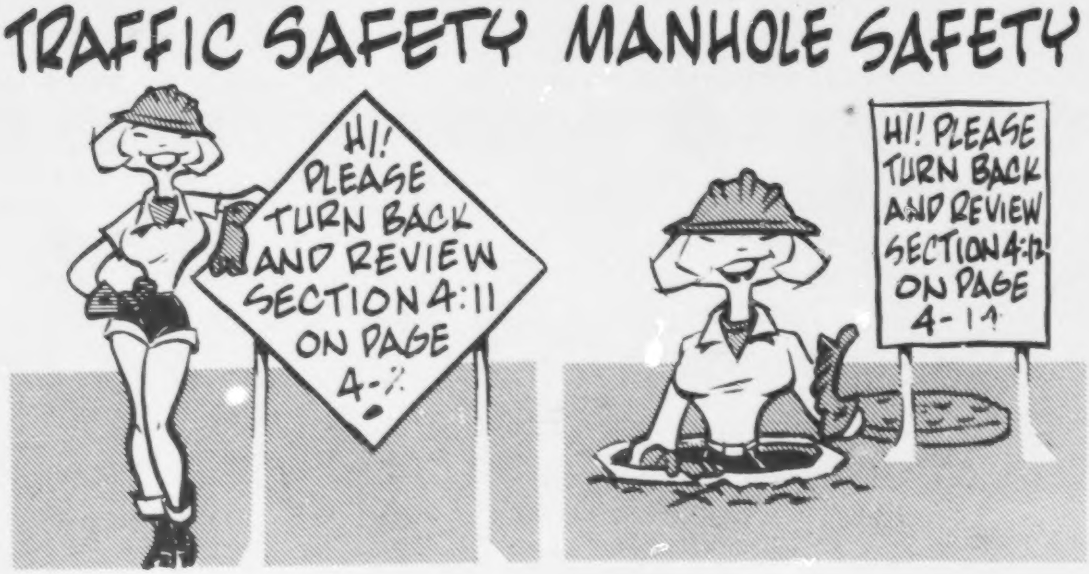
5.23C How does flushing help to control rodents and insects in sewers?

5.23D What are the manpower requirements for a flushing crew:

5.232 Equipment Set Up and Flushing

Determine whether to use a tanker or fire hydrants or both as a source of water for the flushing operation. Start the flushing operation at the extreme upstream end of the collection system.

Place the water line over the manhole and protect the equipment and working area with sufficient safety cones, flags, and warning signs. Follow the directions in Section 4.1, Traffic and Manhole Safety.


TRAFFIC SAFETY
MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-7
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-11

A good visual inspection should be made of the manhole condition. If the water has been backed up, there will be evidence of debris in the shelf area and high water marks indicated by a grease ring. The general condition of the manhole, by number, should be part of the report and recorded at this time.

The manhole should be cleaned with the pressure hose. Since you will want to get more water and move on as quickly as possible, clean the manhole first. Use a pressure hose to clean the manhole and wash the manhole cover casting, cone, barrel, and shelf of the manhole (Maintenance Man I).

The amount of water you will dump into the line will be related to the amount of flow at the time of flushing. The entire water load may not have to be dumped in one manhole. After you have dumped some of the water, observe if there is any evidence of the water backing up.

If the flushing water backs up into the manhole, stop the addition of flushing water or reduce the application rate to prevent flooding of connected residential and commercial services. Observe the water flowing in the downstream manholes and look for signs of grease, roots, or other debris that are creating the restriction. If the restriction is caused by a heavy deposit of wastewater solids, flushing may move the cause of the restriction down the line to a manhole where it can be removed or broken up by spraying with the tank washdown hose and flushed on downstream. If the deposit is caused by roots or grease, prepare and submit a note or work order to have that segment of the line cleaned by using the proper equipment to remove the restriction.

Close the manhole and go to the next downstream manhole. Inspect this manhole as outlined above and clean it completely with the washdown hose.

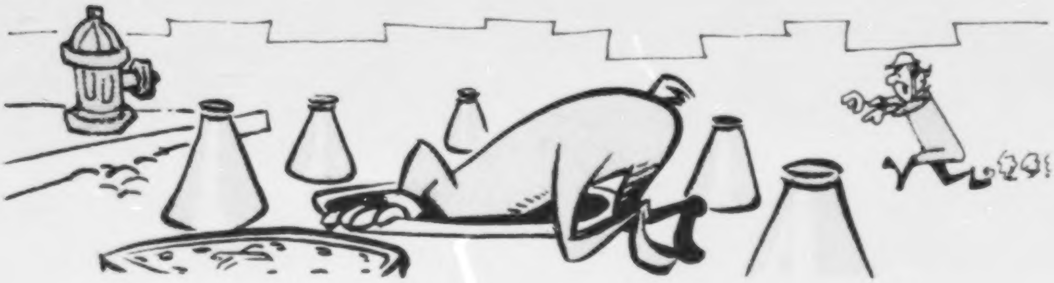
This operation will be repeated from manhole to manhole. As long as heavy flows are observed in the manholes, the operation is progressing satisfactorily. If the flows decrease, look for a stoppage by looking for flows backing up in the upstream manhole. If there is no evidence of a stoppage and flows are declining, more water will have to be introduced to maintain cleansing flows for the flushing operation.

The cleaning at each manhole with a hose takes only a few minutes, but this is the time and place where you should be alert for those items referred to in the beginning of this chapter - foreign material, grease, sand, and roots that can cause problems or indicate problems are occurring.

How many feet of sewers can be flushed by a crew in one day is difficult to estimate because of the many problems of manhole location, traffic conditions, and other obstacles. As much as 20,000 feet or more of sewer and many manholes can be flushed in a day if you do not encounter too many problems. Daily production depends upon the number of manholes that have to be entered and cleaned, plus their condition and location. Whether manholes are located in rear easements and whether flushing can be accomplished by laying a fire hose from a hydrant or from the tank truck to the manhole in a backyard have considerable influence on the time required to flush a line.

5.233 Precautions and Safety

Safety measures need to be followed carefully at all times, from properly protecting the equipment and working area with safety cones to checking manholes for gases found in sewers (toxic and explosive gases and oxygen level).



When flushing, the turbulence may force accumulated gases from dislodged debris or slimes downstream, so care must be taken at all times.

This method of cleaning presents problems very similar to those of balling. Consideration has to be given not to put more water into the collection system than it can handle. Care must be given that a stoppage is not caused which in turn may flood a residence or business. The amount of material and debris being flushed through should not be allowed to accumulate. Care is needed in this respect, especially when first starting a flushing program.

5.234 Records

Since many manholes are going to be opened and cleaned during the flushing operation, there is no better time to make records of defects, leaks, roots, and other problems (see Section 4.3, Inspection of Manholes). In addition, the amount of grease or other material visible also can be recorded. Also see Section 5.18, Records.

5.235 Summary

As mentioned at the outset, flushing can be part of a sewer cleaning operation in conjunction with other mechanical clearing equipment, especially the power rodding machine. The power rodder can cut roots and grease from the walls and joints of pipe, but the removal of that material is dependent upon normal flows unless a flushing unit is used. Flushing is most effective during the power rodder's operation, but can follow at a later time. Flushing is not as effective as balling or high velocity cleaning because sufficient velocities are not developed to move grease, grit, and heavy debris. A flow velocity of 2.5 feet per second will prevent the deposition of solids in a sewer, but once solids accumulate the flow velocity from flushing is not high enough to clean the sewer.

QUESTIONS

5.23E Where do you start a flushing operation?

5.23F How is a manhole cleaned?

5.23G What factors influence the length of line that can be flushed in one day?

5.23H What safety precautions must be taken during a flushing operation?

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5.24 Scooters

The scooter (Figure 5.14, 5.15 and 5.16) is another cleaning tool found to be very effective for cleaning wastewater collection systems by using water pressure. The scooter is designed to be self-propelled in gravity collection systems and operated similar to a balling operation. The operation is quite simple and again the cost is considerably less than the cost of some other cleaning methods.

Basically the scooter is a framework on small wheels with a circular metal shield at one end which is rimmed with a rubber coating. The top half of the shield is hinged and is controlled by a chain-spring system. The lower half of the shield is fastened with bolts to the front of the undercarriage. The flow of water behind and around the scooter is controlled by hinging the upper half of the shield to the scooter. This allows for hydraulic cleaning action and control of the flow of water in the line at the same time. Smaller scooters may be hinged only where the shield is attached to the scooter.

The scooter is capable of removing large objects and such other material as brick, sand, gravel, and rocks. Scooters are considered more effective in larger lines (over 18 inches) and have been used to remove grease in these lines. Even inverted syphons with angles of less than 22-1/2 degrees can be cleaned with the scooter.

Since the scooter is dependent upon water pressure behind it, caution has to be used where sewers are shallow or there is a danger of flooding homes or business property because of the build up of water in the sewer.

Scooters are available in sizes from 6 to 96 inches. The same undercarriage is used for some of these sizes. For instance, one carriage frame will adapt to shield sizes to clean 8 to 15-inch diameter pipes, and another frame will be used for 15 to 36-inch diameter pipes.

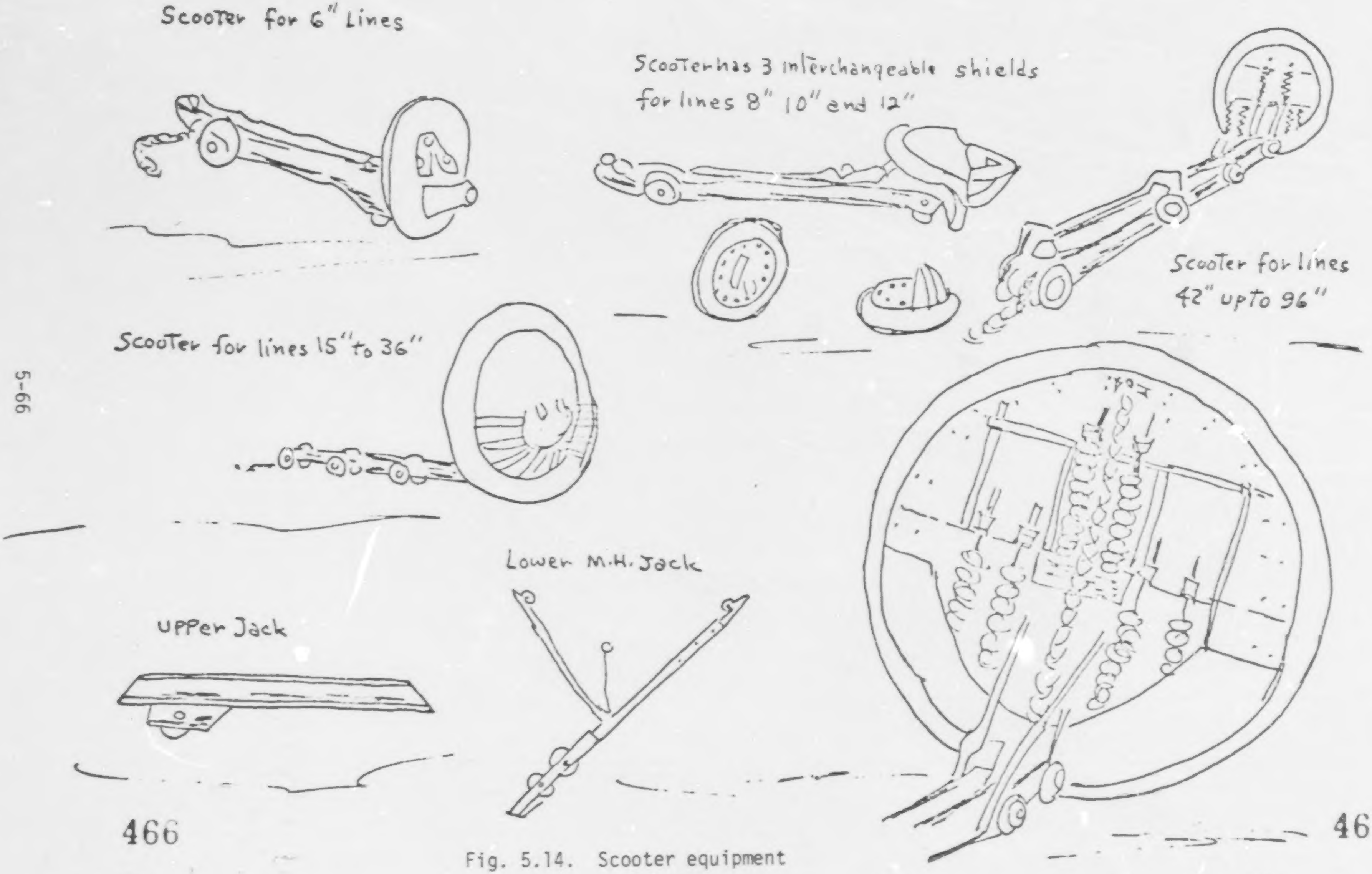
Scooter for 6" Lines
Scooterhas 3 interchangeable shields
for lines 8" 10" and 12"
Scooter for lines 15" to 36"
Scooter for lines
42" up to 96"
Lower M.H. Jack
Upper Jack

Fig. 5.14. Scooter equipment

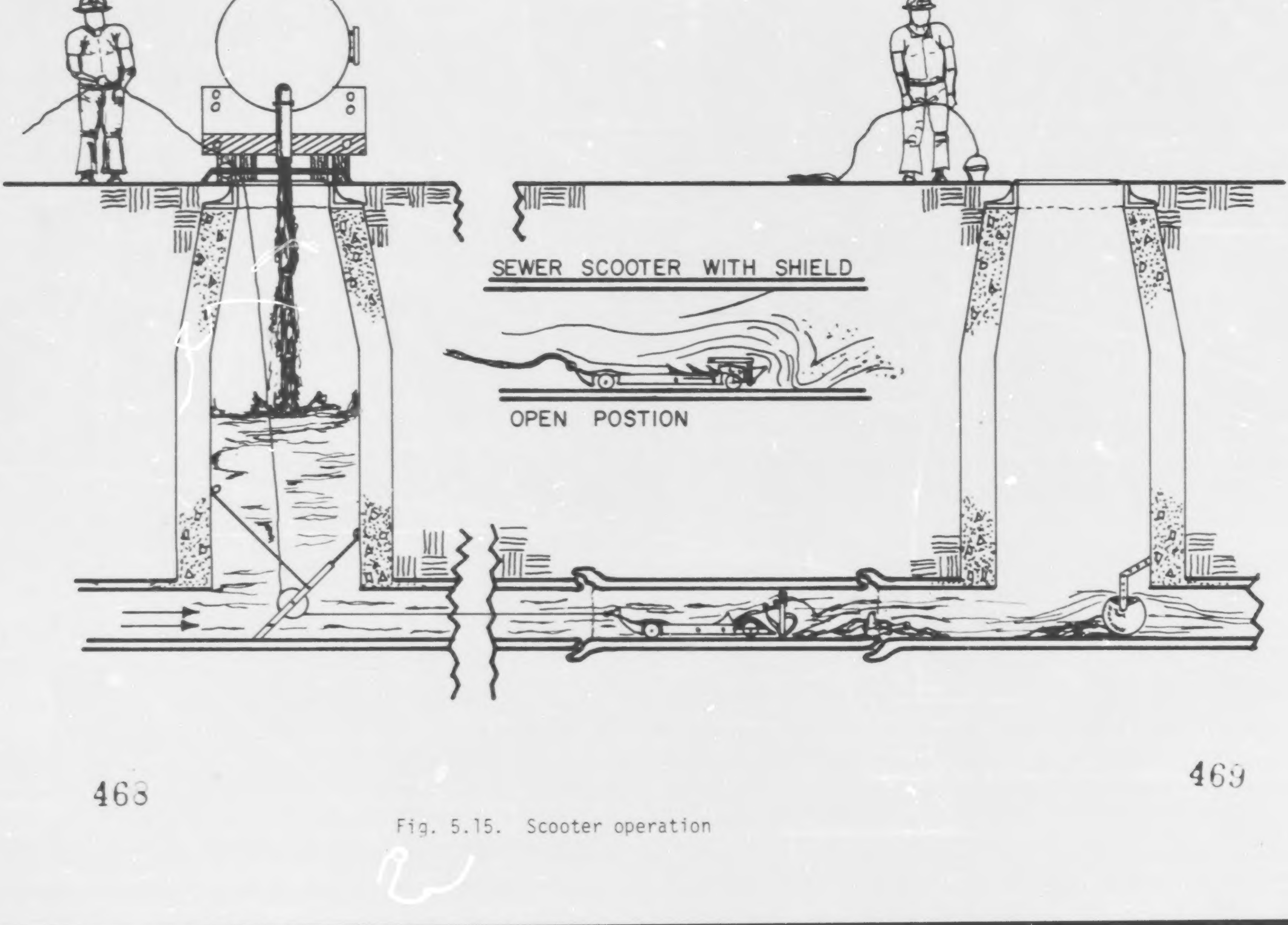
SEWER SCOOTER WITH SHIELD
OPEN POSTION

Fig. 5.15. Scooter operation

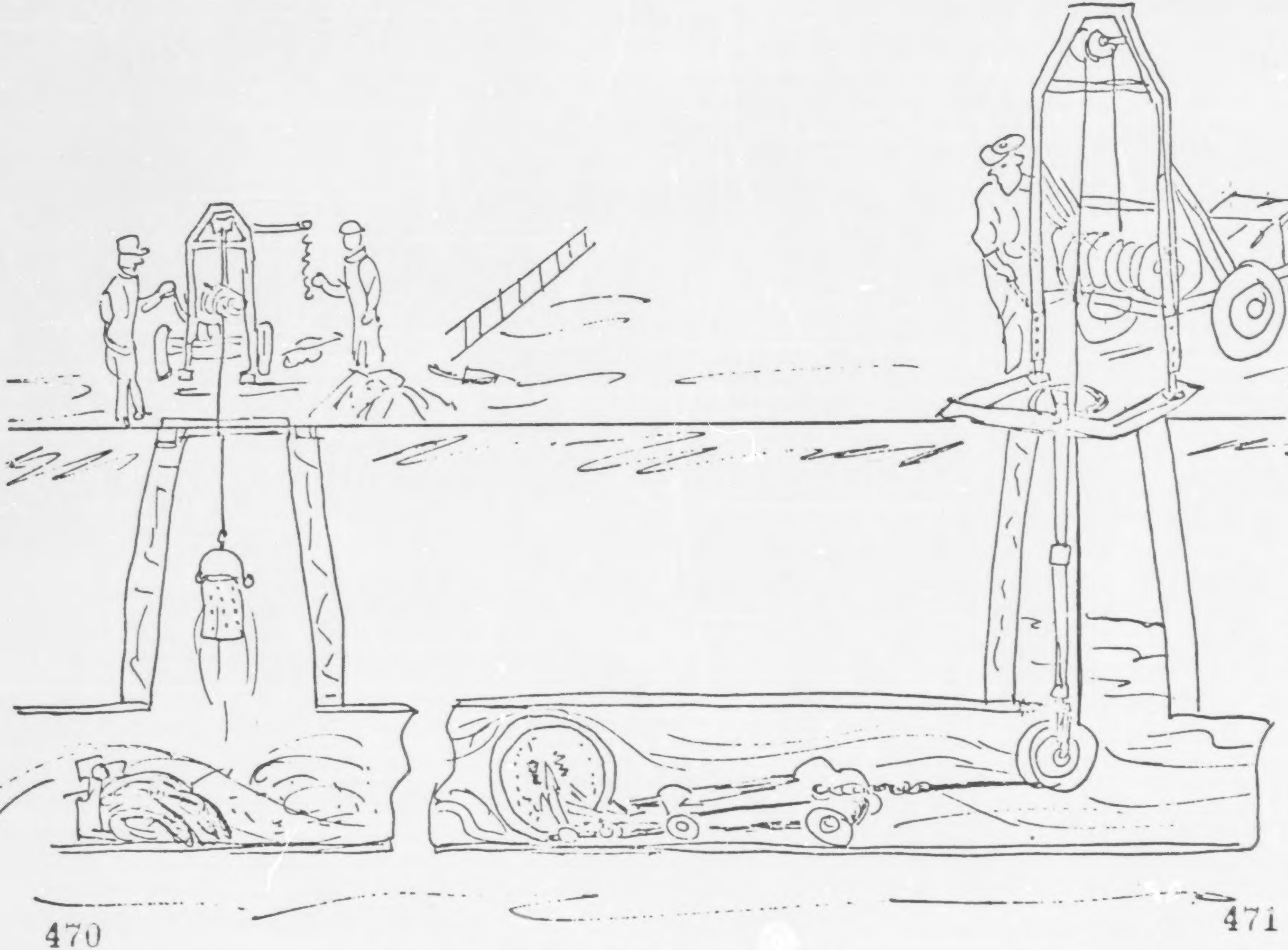

Fig. 5.16. Scooter cleaning larger lines

On larger sizes, stabilizing weights are used on the tail section of the carriage frame to counteract the head pressure during the cleaning operation.

The head shield on the larger sizes is designed to hinge into two or three parts. This compensates for the high head pressures when folding the head shield to allow water to pass. A spring-loaded mechanism allows the upper section to fold first, thus releasing the initial pressure. As the head pressure decreases, the middle section can be folded by a continued pull on the shield control cable.

Large units are not only heavy to handle, but difficult to get through small manhole openings. By being able to fold the head shield, the scooter can be installed in most instances without dismantling.

QUESTIONS

5.24A What causes the cleaning action of a scooter?

5.24B Scooters can be used to remove what kinds of material from sewers?

5.24C What precaution must be exercised when using a scooter?

5.241 Manpower and Equipment

Three workers are needed for safe, efficient operation of the small sizes of scooters (one Maintenance Equipment Operator and two Maintenance Man I). Generally, sewers up to 12 inches in diameter can be cleaned by this method using a hand winch. Fifteen-inch diameter and larger pipe require power drum winch cables. With additional equipment, the operation may require an increase in manpower to handle both ends of the operation.

In addition to the scooter, the following equipment will be needed:

- A tank truck (1,000 - 2,000 gallons)
- Pickup truck
- Debris traps, control lines, and storage reel
- Upper and lower manhole jacks
- Roller cable guides
- Power drum winch
- Safety equipment (See Chapter 4, Section 4.1, Traffic and Manhole Safety)

The control line may be plain manila rope or synthetic rope for small lines and steel cable on the power winch for larger lines. The synthetic rope is lighter and stronger than plain manila and will float. Synthetic rope does not mildew and will not have to be dryed after use, but it has been known to deteriorate rapidly without warning due to some of the chemicals in wastewater.

The reel for storing the control line should hold 1,000 feet and be portable and easy to coil and uncoil.

When a powered drum is needed for the larger size scooters, a standard bucket machine or balling machine cable drum and winch may be used to control the scooter movement down the line. A powered drum is required because of the heavy force of wastewater built up on the shield. A double drum machine is recommended when using a second cable for tripping the head shield.

These winches are trailer mounted with stabilizer legs and can be installed firmly over the manhole while in operation. Because of the size of the larger scooter and the tremendous pressure of water behind the head shield, strong steel cable is needed in place of rope.

The manhole jacks or rollers are essential to guide the control lines into the sewer without causing unnecessary wear as the control lines are pulled back and forth in operating the scooter.

The debris trap is installed in the downstream manhole from the working manhole to trap any material worked loose during the cleaning operation. The trap is designed to allow water to pass and to hold back the debris. If the trap hinders the cleansing action around the shield when the scooter nears the trap, it can be removed and the debris shoveled out of the sewer.

Other tools and equipment include a manhole shovel, debris bucket and hand line, boots, gloves, ladder, 100 feet of firehose, hydrant wrench, water meter, air gap device, and manhole lifter.

If the debris removed from the line is to be hauled away by the cleaning crew, perhaps an additional 3/4-ton truck will be needed. Often the same truck is used for hauling the cleaning equipment, therefore reducing the overall cost of the operation.

QUESTIONS

5.24D How many workers are needed on a scooter crew?

5.24E How does the debris trap installed in the downstream manhole work?

5.242 Equipment Set Up

Before starting the cleaning operation, safety measures need to be taken to warn and control traffic when working in the street and to insure safe working conditions in manholes. Read Section 4.1, Traffic and Manhole Safety, for safe procedures.

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-17

A suitable debris trap should be installed at the lower manhole so there is no delay in the operation once the scooter is installed and ready for use. Fasten the control rope or cable to the control chain of the scooter and lower the scooter into the manhole. After the head shield end of the scooter is inserted into the downstream line, install the lower manhole jack (Figure 5.14) or control cable guide and secure firmly. This will allow the control cable to take the strain without rubbing on the sharp edge of the pipe during the cleaning operation. If an upper manhole jack or roller is needed, it should be installed next.

During this time the head shield of the scooter will act as a plug and a head of water will start building in the manhole. This can be controlled by pulling firmly on the control line, which in turn will fold the upper portion of the head shield and allow the excess water to flow on down the sewer. This spring folding mechanism is so designed for a scooter up to 12 inches that a single control line can be used.

QUESTIONS

5.24F What must be done before equipment is set up in the street?

5.24G What is the purpose of the manhole jack or control cable guide?

5.24H During set up, how can the level of water in the manhole and sewer above the scooter be controlled?

5.243 Cleaning Operation

Let the scooter go downstream a few feet and test the folding mechanism of the head shield (Maintenance Equipment Operator). Give the control line a short, smooth pull back two or three feet and hold. If the build up of water in the manhole starts to go down, you will know the folding mechanism is working properly. If the folding mechanism does not work properly, pull scooter back out of manhole and look for cause of problem by inspecting shield release mechanism for proper operation.

When the scooter is working properly, continue the operation by allowing slack in the control line. The slack will permit the shield to return to the upright position and the water pressure will increase behind the scooter. Allow the scooter to work its way downstream, keeping a tension on the control line. A continuous flow of water and a steady tension on the control line will insure a smooth cleaning operation.

Attention must be given to the amount of head or water in the manhole above the invert, the best cleaning action results when the depth of water in the manhole is three times the pipe diameter. For an 8-inch line, on a flat grade, 24 inches of water above the invert of the manhole will provide sufficient head for cleaning and not flood most homes without basements. Higher wastewater levels in the working manhole increases the scooter cleaning efficiency, but causes a greater risk of flooding. The cleaning efficiency of the scooter is increased as pipe size increases. This is due to the increase of head pressure and the water scouring jet action between the head shield rim and the pipe walls.

This high turbulence will force the debris to move downstream ahead of the scooter. If the flow in the collection system is not sufficient for effective cleaning, you will have to add more water to the upstream manhole by using water from the tank truck or from a fire hydrant.

If the scooter slows or stops during the operation, it is probably due to an accumulation of material ahead of it. This problem also may be indicated by a sudden rise of the water in the working manhole. When material builds up ahead of a scooter, give the control line a short, smooth pull back four or five feet. This will allow the upper half of the head shield to fold back and a surge of water to flush the accumulated material on downstream.

Continue repeating this operation until the level of water in the working manhole stays fairly constant, at the pre-selected level, indicating normal operation.

Continue this operation until the scooter has reached the downstream manhole.

Someone must watch the flow of material into the lower manhole to prevent a buildup of material that could flow over the debris trap (Maintenance Man I). If this occurs, loosened material is lost farther down the line and this manhole itself could become plugged. Remove the debris before the cleaning operation is allowed to continue. Debris removed requires additional help because flow control has to be maintained at the upper manhole. Notify or signal the operator of the scooter to shut off any extra water being put into the manhole and hold up the scooter's progress.

Before entering the manhole, recheck for gases found in sewers and equip the worker with a safety harness, hard hat, and gloves. The material will be scooped into a suitable debris bucket and brought to the surface with a handline. Help must be topside during this operation.

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Set up for scooters, sizes 15 inches and up, differs from smaller scooter sizes because a second control line is used to trip the head shield and powered drum equipment is used instead of the hand line method.

If a bucket machine or balling machine winch is used to guide the scooter down the line, they will be equipped with steel cables. A 3/8-inch cable will be large enough to control the scooter and 1/4-inch cable for the control of the head shield.

The cable guides would differ in that two cables instead of one will be working in the line and they both should run over a roller to prevent damage to the cable.

The powered equipment usually is set up over the working manhole with the control cables running straight down into the manhole.

The bucket machine or balling machine winch, usually trailer mounted, has stabilizer legs which give a firm installation.

Trapping of material at the lower manhole also will differ on larger lines. The standard elbow style debris trap will do an excellent job on lines up to 15 inches. In larger lines the amount of flow has to be considered. Usually all but large objects will break up and be carried with the flow. To trap these larger objects, a grill type device or bar screen can be used which will allow the flowing of water to pass through the manhole.

When the cleaning operation is completed, the scooter is removed at the lower manhole and the control cables wound back on their respective drums.

The lower manhole should be cleaned of debris and the trapping equipment removed.

The material removed should be loaded for disposal and the street area cleaned as needed.

QUESTIONS

5.24I How can you determine if the folding mechanism is working properly when the scooter starts downstream?

5.24J What is the recommended depth of water in a manhole during a scooter cleaning operation?

5.24K What must be done if flow in the collection system is not sufficient for effective cleaning?

5.24L What could cause a scooter to slow or stop during the cleaning operation?

5.24M When material builds up in the line and slows or stops the scooter, what can be done to correct the problem?

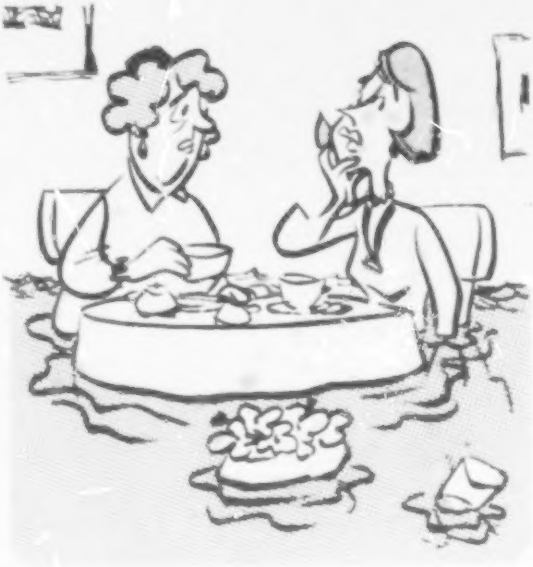
5.24N Why should someone watch the flow in the downstream manhole during the cleaning operation?

5.24O What must be done before debris can be removed from a manhole?

5.244 Precautions and Safety

As with all cleaning methods, certain precautions need to be taken before and during the operation.

One of the most important precautions for this method of cleaning is to determine if a build up of water (head of water in the working manhold and in the sewer being cleaned) will flood a residence or business. The scooter requires a good head pressure to function effectively.



Examine the manhole structures on large lines to be sure the sewer scooter can be installed.

More time is needed to set up and remove the larger units. Allow for this time when preparing work schedules.

Always examine cables at start and finish of each section to avoid having a cable break when the scooter is in the middle of a sewer.

5.245 Records

See Section 5.18, Records.

5.25 Kites, Bags, Tires and Poly Pigs

Kites (Figure 5.17), bags (Figure 5.17), tires and poly pigs (Figure 5.18) describe equipment used to clean larger diameter sewers. For example, instead of using a sewer ball to clean a large diameter sewer, use a tire slightly smaller in diameter (2 inches smaller) than the sewer. With a small head (2 feet) on the sewer, the velocity of water flowing around the outside of the tire will create a cleansing velocity like the velocity around a sewer ball. Kites are called parachutes too. Poly pigs are frequently used in force mains.

The procedures and precautions for using either kites, bags, or tires are similar to those for balling in Section 5.21. Poly pigs are used in force mains similar to balling, but a cable usually is not attached to the poly pig.

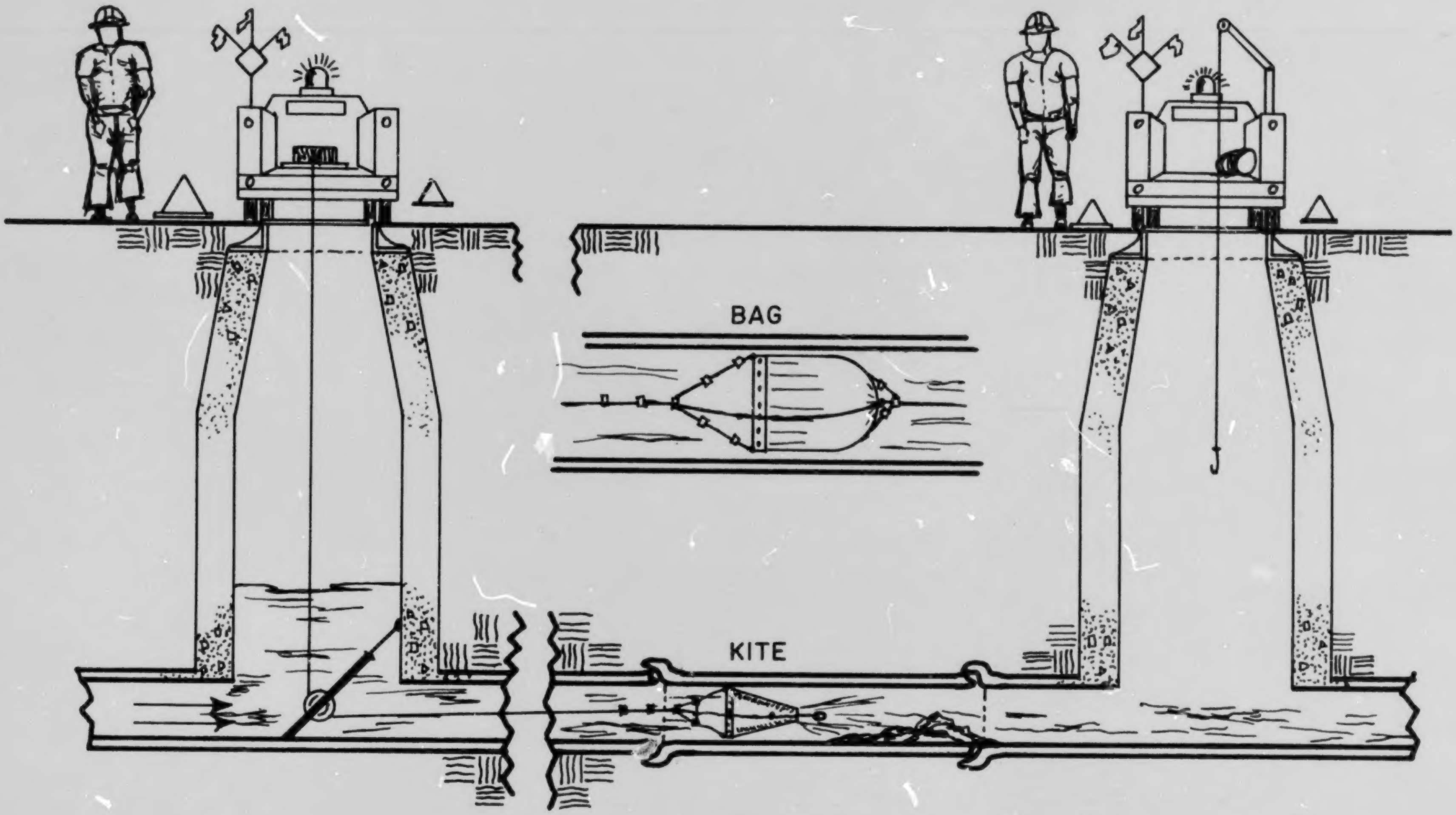
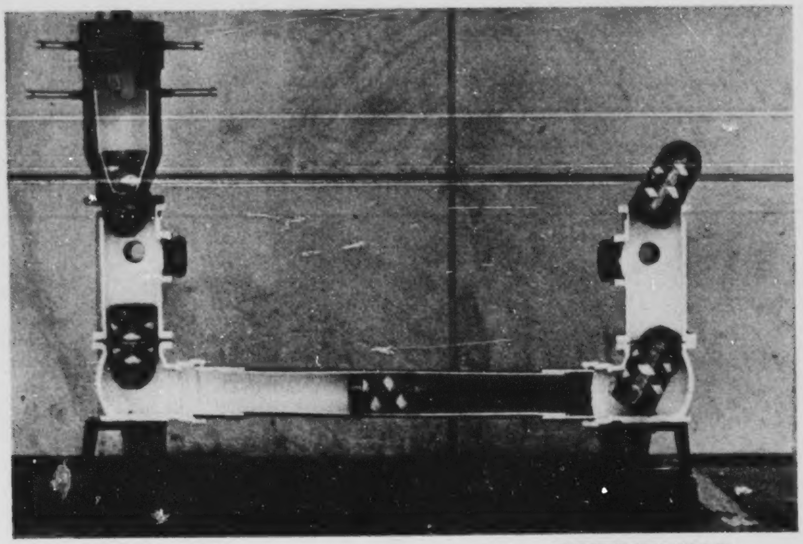
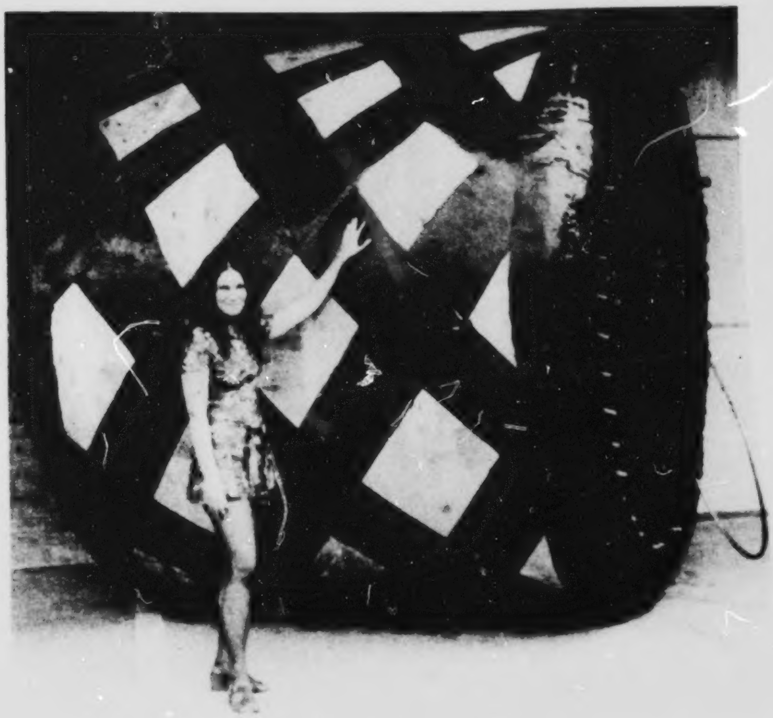


Fig. 5.17. Kite or bag cleaning operation


LAUNCHING
RETRIEVING

Use of poly pig in force main



Nine-foot diameter poly pig
Typical sizes range from 4 inch to 60 inch

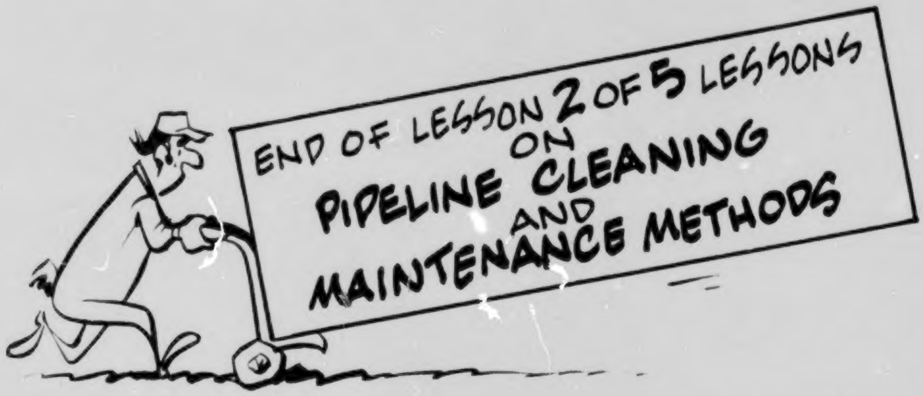
Fig. 5.18. Poly pig
(Courtesy of Girard Polly-Pig, Inc.)

QUESTIONS

5.24P Why should the cables be examined at the start and finish of each section?

5.25A Instead of using a sewer ball, how are larger diameter sewers cleaned?

5.25B How are force mains cleaned?


END OF LESSON 2 OF 5 LESSONS
ON
PIPELINE CLEANING
AND
MAINTENANCE METHODS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 2 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 1.

7. How do hydraulic cleaning methods clean sewers?
8. What precautions have to be taken during all hydraulic cleaning operations?
9. What would you do if a sewer ball became stuck in the middle of a sewer during a balling operation?
10. Why do sewer cleaning crews often use hand signals?
11. How fast and how far into the sewer should the nozzle of a high velocity cleaner be allowed to go?
12. How effective is flushing?
13. What types of conditions are best suited for the use of a sewer scooter?

5.3 MECHANICAL CLEANING

Wastewater collection line cleaning techniques described in this section rely on a mechanical action to clear the sewer. This clearing action results from the material in the sewer being removed by a scraping, cutting, pulling, or pushing action caused by a mechanical device or machine. Clearing techniques outlined in this section include bucket machines, power rodders and hand rods.

5.31 Power Bucket Machines

5.311 Use of Power Bucket Machines

Sewers are purposely designed to develop sufficient velocity to provide a self-cleaning action and to convey solids through the system to the wastewater treatment plant. When deposition of solids occurs in a sewer, first consideration should be given to hydraulic cleaning techniques to remove the solids from the sewer. Hydraulic cleaning techniques include balling the line (Section 5.21) and using a high velocity water jet (Section 5.22). These techniques are used due to their simplicity, effectiveness, and the costs of removing the deposited solids when compared with other sewer cleaning techniques.

There are instances when the hydraulic techniques are not the best method of removing roots or deposits of solids because of the volume, size, weight, or type of material that may be found in the sewer.

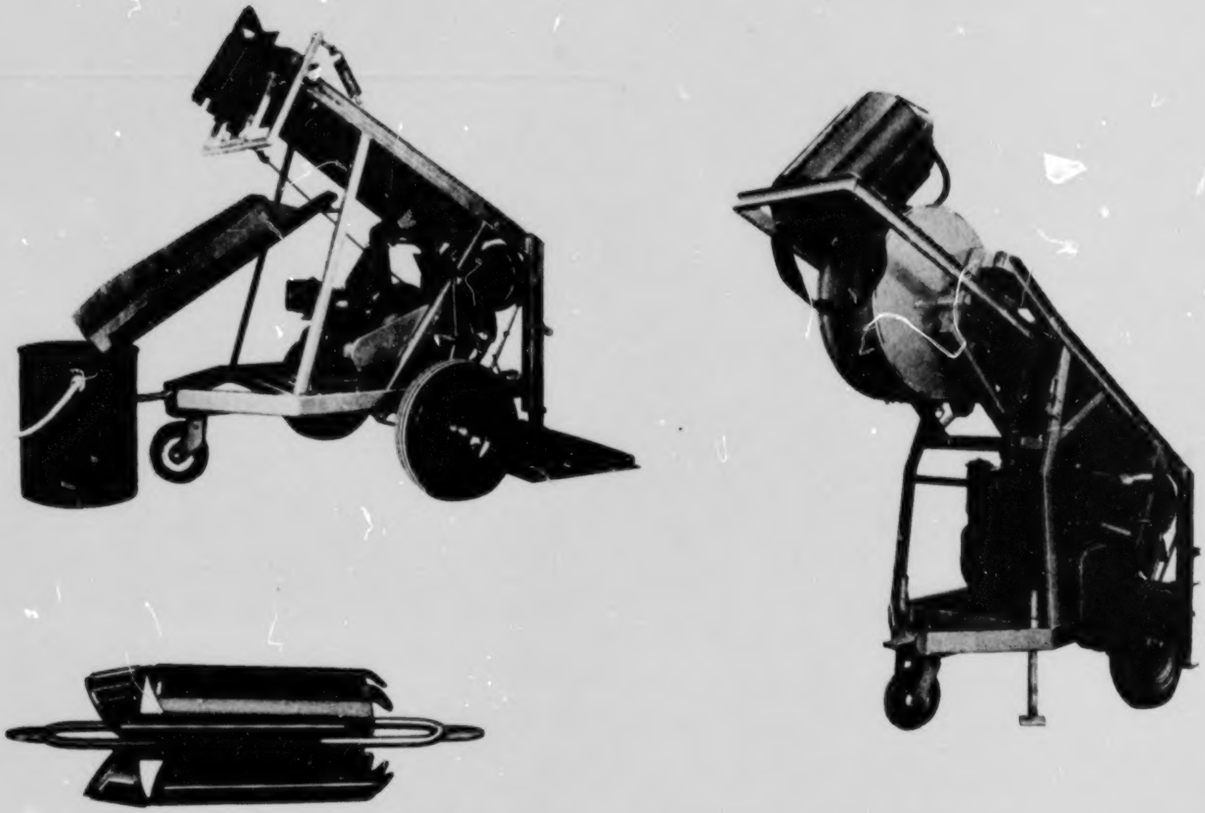
This material may be lumped together or spread separately along the line. Types of deposits include silt, sand, gravel, or some type of industrial solid waste. The entry of silt, sand, gravel, and rocks into the collection system is often traced to some damage either to the sewer line or manholes, or a section where repairs were made to the system. Pipes or manholes may be broken by various construction projects, grade changes of streets, earthquakes, or excessive loads from vehicles and heavy equipment. When a pipe breaks, large quantities of debris can enter the collection system.

When there is an indication that a sewer is failing, and that sand or mud is entering the sewer, do not use a high velocity cleaner. Nozzle action develops a negative pressure that can hasten the collapse of a bad section of pipe. A bucket machine can be used to remove the sand or mud when proper care is exercised. If possible, televise the sewer as soon as possible to determine the cause of the problem and the condition of the pipe.

To clean a line after a pipe breaks, the power bucket machine can be used effectively both before and after repair to remove the heavy deposited material. Next clean the sewer hydraulically to restore it to full capacity. A damaged line must be repaired to prevent the entry of more material.

The power bucket machine is a necessary maintenance tool, but it should be used only when absolutely necessary. They are heavy and the operation is a slow process. Power bucket machines are used mainly to remove debris from a break or other debris that can't be removed by hydraulic cleaning techniques. Also they can be used as scrapers with a root cutter or porcupine. They should not be used as a routine cleaning tool on a regular basis. Broken lines must be repaired and kept tight so the bucket machine won't have to remove debris from the same broken pipe location again.

Figures 5.19, 5.20, 5.21 and 5.22 show power bucket machines, accessories and the equipment set up.



STANDARD BUCKETS

Fig. 5.19. Power bucket machines and standard bucket
(Courtesy of Municipal & Utility Division, Rockwell International)

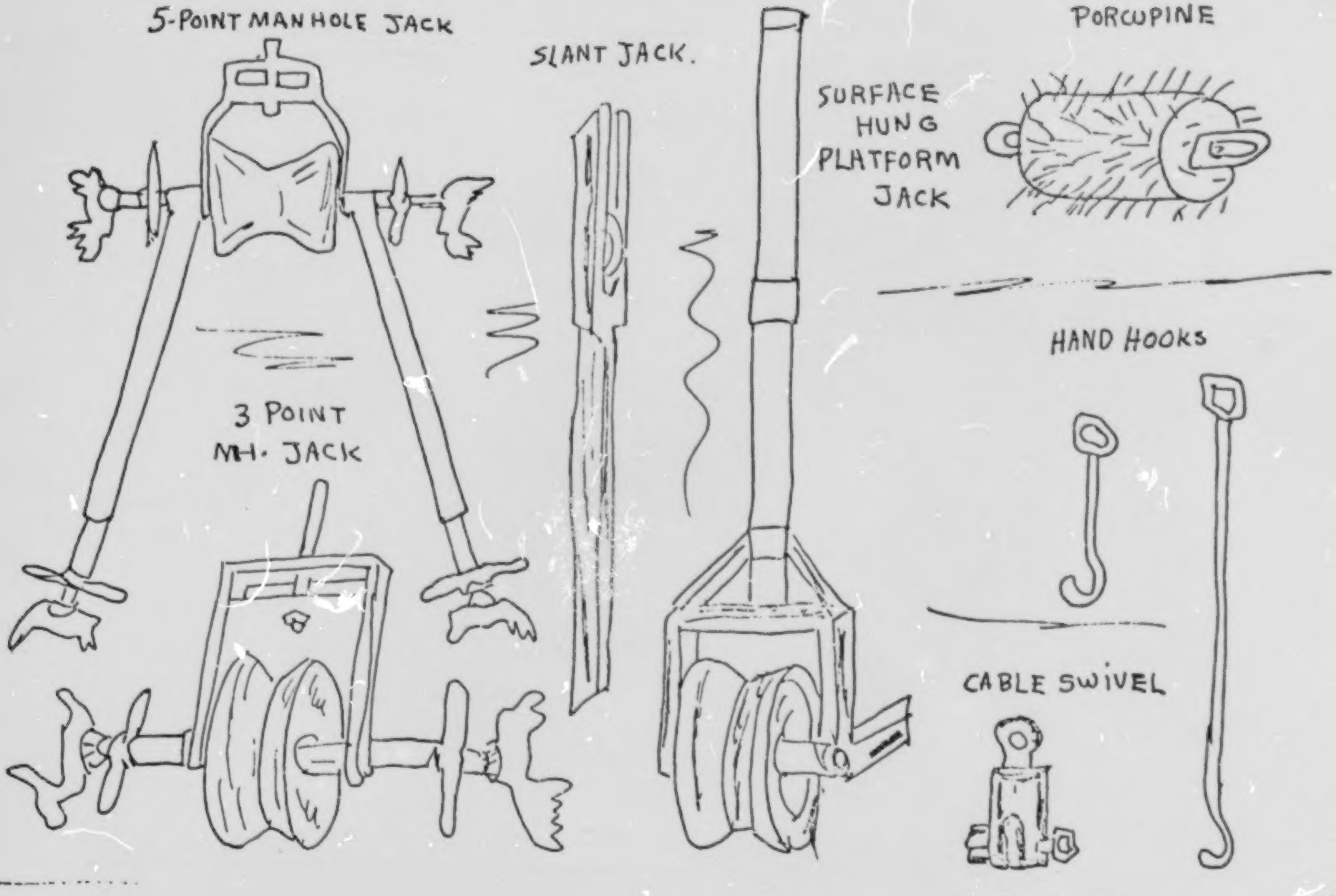

5-POINT MANHOLE JACK
SLANT JACK.
SURFACE HUNG PLATFORM JACK
PORCUPINE
HAND HOOKS
3 POINT MH. JACK
CABLE SWIVEL

Fig. 5.20. Power bucket machines and accessories

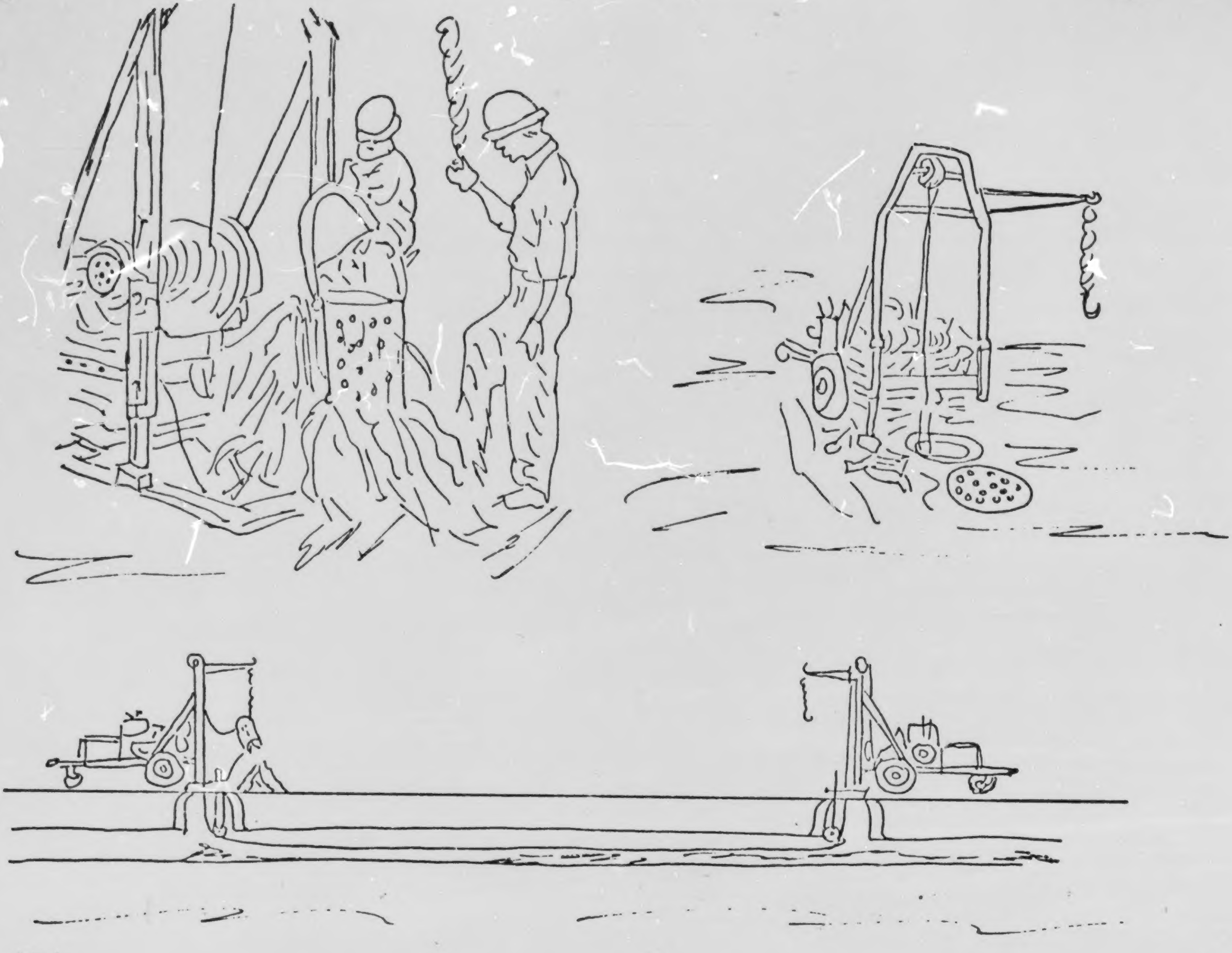
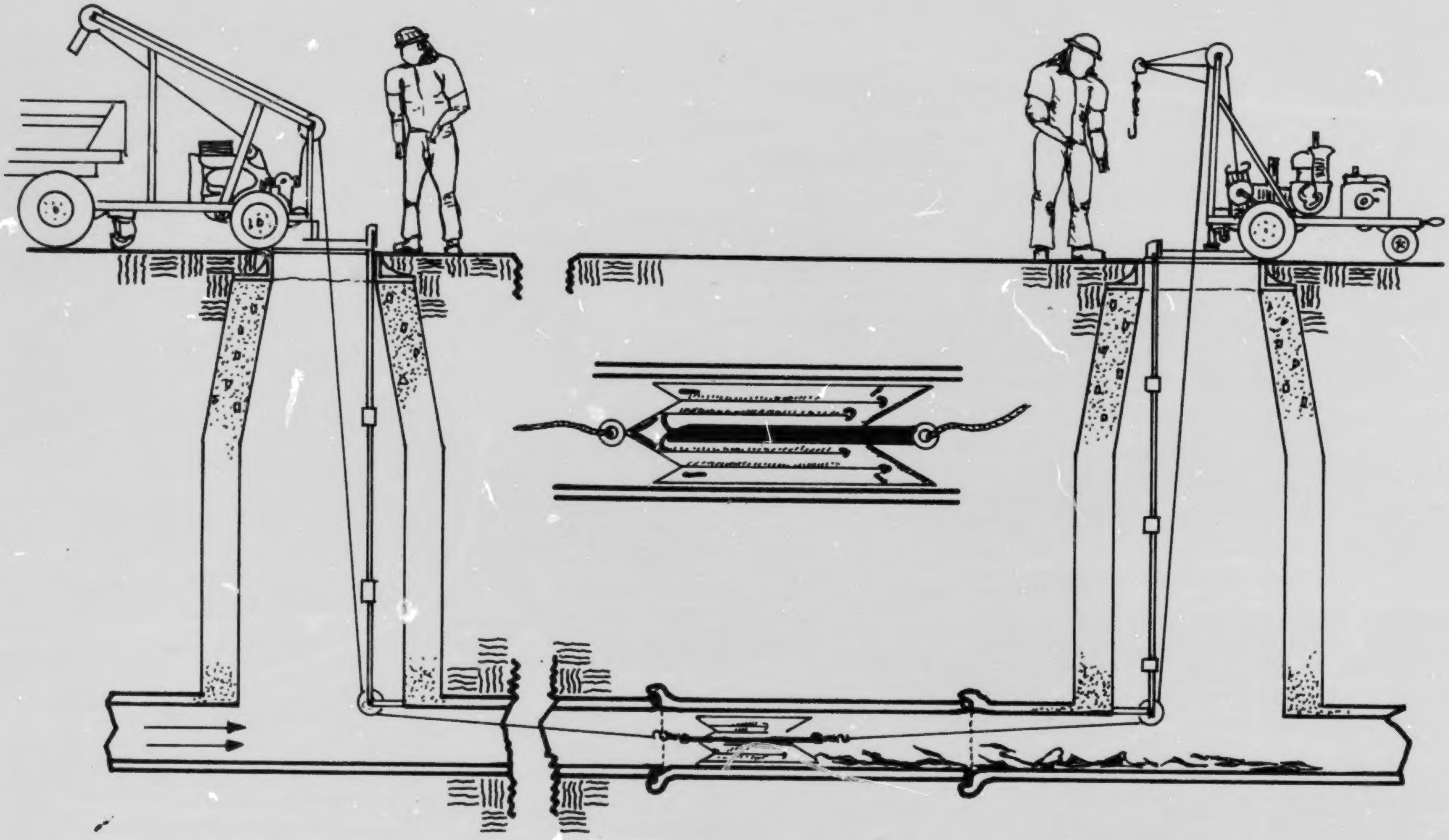


Fig. 5.21. Power bucket machines



NOTE: Working machine is at the upstream manhole.

Fig. 5.22. Power bucket operation

QUESTIONS

5.31A Identify two sewer line mechanical clearing techniques.

5.31B What clearing techniques should be given first consideration when solids deposit in a sewer?

5.31C Under what conditions would hydraulic clearing techniques not be feasible?

5.31D When should power bucket machines be used?

5.312 Manpower and Equipment

Buckets range in size from six inches to thirty-six inches in diameter. Volumetric capacity of the buckets range from 0.13 cubic feet to 8.5 cubic feet. An 18-inch diameter bucket will pass through a standard 24-inch diameter manhole opening and has a volume of approximately 1.6 cubic feet.

The bucket machine is usually trailer mounted (Figure 5.19), but can be truck-mounted. Trailer-mounted bucket machine units must have a pintle safety hook attached to the truck that tows the trailer to the job site. Also a wire cable and shackles should be placed around the truck frame and to the frame on the bucket machine for added safety in case the pintle hook fails.

The bucket machine units have a steel framework on which is mounted a gas engine and a drum winch. The drum is coupled to the engine through a controllable drive train, usually a chain and belt drive combination. The drum is capable of holding 1,000 feet of 1/2-inch steel cable and is mounted on the framework in such a position that it can be centered over a manhole. The framework includes a vertical "A" frame of sufficient height to allow the cleaning bucket to be lifted above ground level.

Two machines are needed for this operation and both are basically the same in design. At least one machine also will be equipped with an additional smaller drum capable of holding 1,000 feet of 1/4-inch steel cable. This drum can be operated separately from the 1/2-inch cable drum. The purpose of the small cable and drum is twofold. One is for the purpose of threading the sewer line from manhole to manhole, and the other is to have a suitable cable which can be left in the line overnight. The drum is, therefore, often referred to as an overnight drum.

An optional addition to one machine may be a chute with rollers and shaker bar which allow the material removed to be dumped directly into a dump truck. Machines without this attachment have the "A" frame as previously mentioned. The machine which does the pulling of the bucket out of the manhole will be referred to as the working machine. It will have a small swinging boom or arm attached to the "A" frame which is used for dumping the full buckets. Operation of this machine will be described later in Section 5.313.

With each bucket machine, equipment will be needed in the manhole to guide the cable into the sewer line without rubbing or cutting into the pipe. At the working machine, use a V-shaped roller (Figure 5.20) of sufficient size to accommodate the size bucket being used. This roller will be held in place by means of a steel pad which in turn is firmly secured flush with the street surface by two adjustable stabilizer legs on the machine. The companion machine may use the same method or perhaps use a slant jack (Figure 5.20) in the bottom of the manhole for the cable to travel over. This would dispense with the use of the pad and roller.

A variety of tools are available for use with these machines and more are being developed, making these machines usable for purposes other than bucketing of debris. Root cutters and insertion pullers can be used with bucket machine power winches.

For this discussion, we will consider the use of the clamshell bucket (Figure 5.19) and porcupine tool. These are available in sizes from 6 to 36 inches in diameter, but sizes under 12 inches are rarely used.

The bucket is of such design that when being pulled into the sewer line the jaws are in an open position. The jaws dig into the deposits of material.

When the working machine pulls the bucket out, the jaws are forced closed by means of a slide action. Any material in or in front of the bucket is scooped up.

The porcupine tool is a steel cylinder having solid ends with eyes cast in them to which a cable can be attached. Many short pieces of cable protrude from this cylinder like a round brush. This tool is quite effective for final cleanup since the bristles have a scrubbing action.

Equipment needed other than that furnished with the bucket machines includes sandtraps, manhole shovel, debris bucket and hand line, manhole lifter, pipe wrenches, and hand tools such as crescent wrenches and pliers.

Safety equipment includes flags, cones, barricades, traffic signs, sewer gas detection equipment, safety harness and rope, and such other safety devices the job setup may require (see Section 4.1, Traffic and Manhole Safety).

Experience has shown that many unexpected repairs occur during the clearing operation. Extra cable swivels, clevises, cable clamps, and other essential accessories should be readily available if not with the machines.

The number of workers needed to effectively conduct the clearing operation will vary, but at least three workers are needed and four workers are recommended. If traffic control dictates, flagmen will also be needed. Manpower requirements:

1. Maintenance Equipment Operator
2. Maintenance Man I
3. Maintenance Man I
4. Maintenance Man II

QUESTIONS

5.31E What is the purpose of the working machine?

5.31F What is the purpose of the porcupine tool?

5.31G How many workers are needed on a power bucket crew?

5.313 Equipment Set Up

Whether the working machine is set up at the upstream or downstream manhole depends on field conditions. In smaller sewers with lower flows the working machine is usually located at the downstream manhole. Under these circumstances there is little tendency for the material being removed to be washed out of the bucket. Also working from the downstream manhole reduces the possibility of a stoppage developing in the sewer below the working area.

Often the working machine is located at the upstream manhole (Figure 5.22) when clearing debris from larger sewers. Under these conditions the debris in the full bucket tends to remain in the bucket because the bucket is being pulled against the flowing water when the full bucket is returned to the working manhole. If flows are low, the possibility exists of a stoppage developing downstream from the working area.

Once this equipment is set up, it usually remains in one position for several hours. Special emphasis is placed on safety measures taken for control of traffic and insuring a safe environment in a manhole (see Section 4.1, Manhole and Traffic Safety).

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14

Bucket machine clearing requires a certain amount of skill in operation of the equipment and this can be obtained only by actually working with the equipment. This method is one of the more expensive operations due to several factors, but mainly the hours involved in setting up the equipment. In the process of bucket machine clearing, it is not unusual to find you cannot complete the job before the end of the day. Because of the time and effort needed to thread the line, the overnight line is left in the sewer. This will be discussed further in Section 5.314, Operation.

During the set up operation, communication has to be established with both the operators at the upstream and downstream manholes. Communication may be either by sound powered telephones, radio, or signals as shown in Section 5.21. A fool-proof system must be devised and used between winch operators because someone can easily be injured if the proper signal is not sent, received, or is misunderstood.

The two machines are positioned over the respective manholes (Figure 5.22); the working machine at the downstream manhole and the backpull machine at the upstream manhole. The pads are placed under the stabilizer feet of the machine and these feet jacked down so sufficient weight of the machine holds the pad in place. The legs also function as a method of leveling the bucket machine. Insert a sand trap or debris trap in the downstream line to stop material pushed ahead of the bucket when clearing.

The lower manhole roller is lowered into the manhole by attaching various lengths of threaded pipe, usually 2-inch pipe in 4-foot sections. With this roller properly situated, the cable and bucket must clear the top of the sewer, the pipe is then secured to the pad by means of a chain clamp device. With this firmly in place, the roller will not lift up when strain is applied to the cable while pulling. Give consideration to this NOW since there is the same pressure exerted to lift up on the roller in relation to the power exerted in pulling with the cable. If there is a set up problem, roller security is one of THE FIRST problems encountered when the clearing operation starts.

As described previously, the upstream machine may possibly be set up with a slant jack type roller (Figure 5.20). If so, the pad and roller, with pipe extensions, will not be needed. Again, make sure the slant jack is secure since this machine will be exerting considerable lift-pulling action also.

To thread the sewer, a synthetic rope can be used. The upstream machine can be equipped with a small drum exactly the same as the "overnight" drum on the downstream working machine. One thousand feet of the synthetic rope can be carried on this drum. Some synthetic rope has been known to deteriorate without warning due to chemicals in wastewater.

To this rope attach a nylon parachute designed and available for such use and allow this parachute to float downstream to the working manhole. A high velocity cleaner may be used to string the line also. Attach the parachute rope to the 1/4-inch steel cable of that machine. A swivel must be used to keep the rope and cable from twisting. The upstream operator engages the small rope drum and pulls the 1/4-inch cable upstream to the machine. Remove the rope drum from the machine so it will not interfere with the operation. Connect the 1/4-inch cable and swivel to the 1/2-inch cable. When ready, signal the downstream operator to engage the small drum of the machine and pull in the 1/4-inch cable, thus threading the sewer line with the 1/2-inch cable. The operator of the working machine will likewise remove the 1/4-inch cable drum.

QUESTIONS

5.31H Why might an overnight line be left in the sewer?

5.31I Why must a fool-proof communication system be devised and used?

5.31J What is the purpose of the swivel between the parachute rope and the 1/4-inch steel cable?

5.314 Operation

The clearing bucket is now ready to be attached to the cable. Experience and history of the sewer line dictates how much smaller a bucket must be than the actual diameter of the sewer. A cable swivel of sufficient size is attached to each bail of the bucket[5] by means of a clevis. The 1/2-inch cables are then attached to the swivels using a clevis. Position the bucket so the jaws will be opening upstream.

Take up the slack in the cable of the working machine (Maintenance Equipment Operator) until the bucket is hanging free over the manhole. Signal the upstream operator (Maintenance Man I) to take in the cable. Hold the brake securely on the working machine to keep the bucket from dropping into the manhole. Experience is gained quickly at this point because special care has to be taken in getting the bucket around the lower roller and into the sewer.

At the start, always make a few short pulls to check out not only the amount of material in the sewers, but also the equipment and the set up. One approach is to try an undersized bucket first to determine if it can be pulled through the sewer. If this works, a larger bucket can be tried because it will remove more material before it is full. As the bucket is pulled upstream into the material deposited in the sewer, a definite resistance can be noticed when the bucket is full.

When the bucket is full, pull the loaded bucket back out the sewer. To start pulling the bucket back, signal the working machine operator after disengaging the machine. Hold a slight amount of brake to keep the cable from spooling too freely as the bucket is pulled downstream. If the working machine is equipped with a footage counter, watch closely as the full bucket nears the manhole. Reduce the speed of pull when the bucket enters the manhole and makes the sudden turn around the lower roller and up to the street surface. If a footage counter is not used, the operator can quickly note the cable wraps and their position on the drum. This technique also can apply when the bucket is being pulled upstream. The operators, by knowing the approximate diameter of the drum, and the number of wraps or layers pulled off, can judge fairly closely the distance the bucket is in the sewer. Bucket location is important to this operation.

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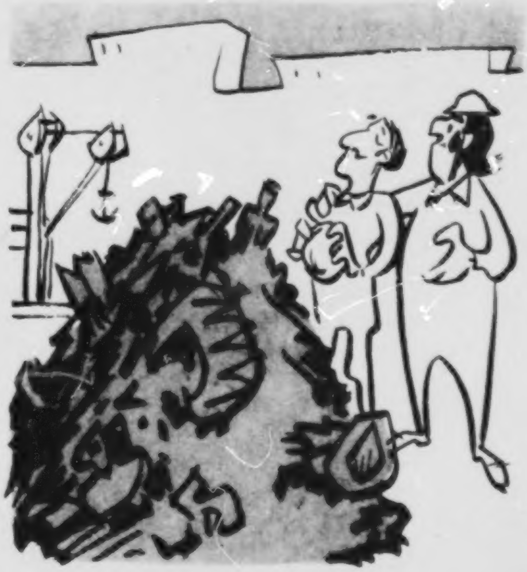
[5] Bucket bail. Pulling handle on a bucket machine.

When the bucket is pulled back out of the manhole and a sufficient distance above street level, the helper will swing the small boom out and attach a hook and short chain to a special eye on one side of the open end of the bucket. With a long hook, this helper will quickly pull the bucket to one side and away from the manhole by engaging the hook on the lower bale of the bucket.



At the same time, the machine operator releases the brake, thus allowing the bucket to drop. When the bucket is suddenly stopped in mid-air by the short chain on the boom, the jaws slide open and allow the debris to spill on the street or into a container or truck. Practice and coordination of this operation between the operator and the helper will result in keeping the pile of debris in one area where it can be loaded and hauled away.

The operator will engage the cable drum, again lifting the bucket enough so the short chain can be unhooked from the bucket. The operation is now ready to be repeated. After several pulls, check the build-up of material against the sand trap in the bottom of the manhole. This material should be removed before it is lost downstream.

When the bucket of the correct size has been pulled freely from the upstream manhole to the lower manhole, it may be advisable to finish cleaning the sewer with the porcupine cleaning tool. Remove the bucket, fasten the two cables together and pull the cable upstream until the swivels are above street level. Attach the porcupine with a swivel at each end and insert it carefully into the sewer. If a slant jack is used, the porcupine may have to be put on in the manhole due to the design of most slant jacks. If a pad and roller are being used, allow the working operator to slowly pull the porcupine into the sewer and then on downstream where it can be removed.

WARNING

DO NOT PULL THE PORCUPINE UPSTREAM SINCE IT HAS A TENDENCY TO SEAL OFF THE LINE AND CAUSE THE SEWER TO BACK UP.

This in turn may cause problems of flooding if there are building laterals connected into the sewer being cleaned.

Since each machine is capable of handling 1,000 feet of cable, often it is possible to pull through or skip a manhole, thus saving another time-consuming set up. Two sections can be cleared at once, provided the sections are in a straight line. A disadvantage of this procedure is that you may greatly increase pipe damage by more trips through the same section of sewer. A short damaged section may become a long damaged section.

If the working machine is equipped with a truck loading chute, the operation of dumping the bucket is done by the machine operator. Loading chutes eliminate loading the material from the street to the truck and considerable clean up. An extra worker is important at this end of the operation even with the chute method of dumping. Often the operator needs help when the controls of the machine cannot be left. When extra help is not available, the danger of accidents is greatly increased. This method of clearing is time consuming; and when the operation is hurried, quality of clearing, equipment care, and safety are often unintentionally sacraficed.

If the job is not complete at the end of the day, the bucket is removed at the downstream working manhole, and the 1/4-inch overnight drum is installed and connected with a swivel to the 1/2-inch cable of the upstream machine. When the 1/4-inch cable is pulled through, it is secured in the upstream manhole in such manner that it cannot come loose. The manhole cover can be replaced.

The 1/4-inch cable and drum are then removed from the downstream working machine and lowered into the manhole and secured.

The pull line will be ready for the next day's set up and considerable time saved.

When work is complete, the reverse procedure of set up is used to remove the equipment from the sewer and the manholes. Hose off buckets and cables. Load the equipment into the trucks and prepare for the next set up or the next day's use.

Final clean up is performed with special care given to washing down and completely cleaning the entire area where debris or wastewater has been deposited on the street surface during the operation.

In these instructions, the set up of this equipment has been to have the working machine at the downstream manhole and to do the actual clearing by going upstream into the material to be removed. This does not mean the reverse procedure cannot be used and it often is. However, conditions in the sewer must be kept in mind and particularly the results of whichever procedure selected. If large amounts of debris and especially roots are encountered when pulling the clearing tool downstream, a stoppage can be caused below the working area. By working upstream as outlined, this danger is practically eliminated. However, use a improper tools and techniques also can allow debris to cause a stoppage downstream. Again, the continuous use of this equipment and the experience gained will govern the choice of the set up procedure.

QUESTIONS

5.31K What size clearing bucket should be selected?

5.31L How can you tell when the bucket is full?

5.31M Where is the debris in the bucket first dumped after the bucket is removed from the manhole?

5.31N Why is a sand trap inserted in the downstream manhole?

5.31O How can the sewer line be cleaned after a bucket has been pulled through the line?

5.31P Should the porcupine be pulled upstream or downstream?

5.31Q Why should the bucket be pulled upstream?

5.315 Precautions and Safety

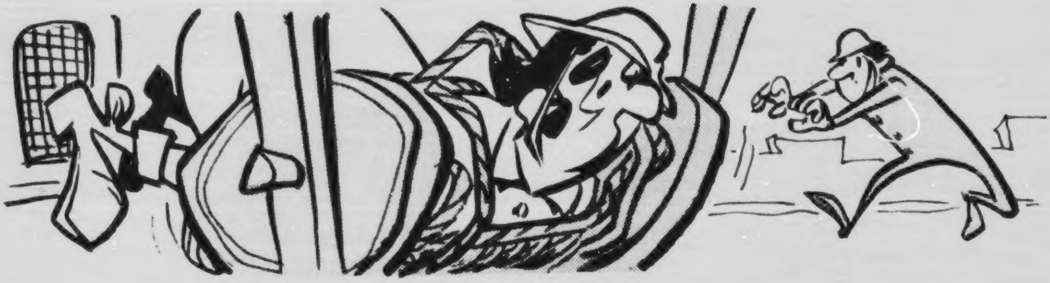
Because a rather large tool is being used in the sewer, any problem encountered which would keep the bucket, porcupine, or other such clearing device from moving can cause water to build up behind it. Prevention of stoppages during clearing should be foremost in the mind of the operator. If there is any question of the clearing tool getting through, try a smaller size and determine if the sewer would allow a larger tool to pass through the sewer. As mentioned previously, it is important to know the location of the clearing tool at all times. Footage counters are recommended; but if they are not available, keep track of the wrap of cable. In the event the clearing tool has to be dug up, it helps to know where it is stuck.

Regularly inspect cable clamps, clevis and swivels, bucket condition, cable condition, and condition of accessories. If a cable should come loose from the bucket on the wrong end for any reason, you may not be able to pull the bucket through the debris to the manhole at the other end.

If a bucket becomes lodged, don't try to force your way through. If pulling the bucket upstream, have the downstream machine pull it back a few feet and try again. Pulling back will open the jaws and likely let the bucket come into the problem area at a different angle. If repeated attempts fail, have the bucket pulled back a few feet, enough to open the jaws, and then hold the brake tightly on the upstream machine while the working machine again pulls. This tends to hold the jaws open and also gives a lifting effect to the bucket.

Be careful when lowering the bucket into the working manhole. Do not allow the cable to tangle or come off the lower roller by keeping the slack out of the cable. Prevent the bucket bail from folding back on the bucket when it is pulled into the sewer because there is no way of its flipping back over when you start to pull the bucket.

Personal safety must be stressed when using cable operated equipment. Be especially careful when guiding cable onto the drums. Keep your hands clear of the drum. Use a manhole hook to guide the cable.



In an instant, your hand or fingers can become entangled and the operator cannot stop the machine fast enough to avoid injury.

New or inexperienced workers should not operate this equipment without proper training and supervision. Some of the safe practices used are techniques acquired through repeated operations and observations of problems encountered during rewinding.

5.316 Records

Since bucket machine clearing is not repeated in the same line any more often than necessary, good records must be kept. Often at a given spot in the sewer line the bucket may "hang up". This could be caused by several possible factors, but if it is a severe problem, a repair at that point may be indicated. Cocked joints can turn into broken joints if the bucket is banged against them continuously and even cause the bucket to become lodged tight. Let this event become part of the permanent record. If repairs subsequently are made, this too can be noted and the next time this sewer is cleaned, the workers will have this information. Also see Section 5.18, Records.

QUESTIONS

5.31R Why must the location of the bucket in the sewer be known at all times?

5.31S Why should the condition of the equipment be inspected periodically?

5.31T What precautions should be taken when working around cable operated equipment?

5.31U Why should particular problems encountered when clearing a sewer be recorded?

5.32 Power Rodders

5.321 Uses of Power Rodders

Power rodding machines use a steel rod to push or pull various clearing tools through sewers (Figures 5.23 and 5.24). These machines are of various designs, but are equipped to store either continuous or sectional rod in a reel type cage in lengths up to approximately 1,000 feet. This reel can be rotated to give turning action at the same time the rod is pushed out or in.

Power rodders can be used for the following purposes:

- A. Routine preventive maintenance.
- B. Scheduled clearing of:
  - 1. Grease deposits
  - 2. Roots
  - 3. Debris accumulations
- C. Threading cable for:
  - 1. Balling equipment (15-inch diameter and larger lines)
  - 2. TV inspection
  - 3. Bucket machines
- D. Emergency use for clearing stoppages.

Power rodders are one of the most widely used methods for clearing a wastewater collection system. Since the machines were introduced for commercial use in the early 1950's, many improvements have been made in design, operation, and clearing tools.

Although other clearing methods play an important role in maintaining the collection system, the power rodder can handle stubborn stoppages of roots, grease, and debris. The power rodder is called for when emergency crews cannot clear a stoppage with hand rods. This could be due to the type or size of stoppages or a distance too great for hand rods to be effective. The power rodder is a handy tool as support equipment to thread cables in lines for other cleaning and maintenance methods. After a sewer has been cleared with a power rodder, it should be cleaned hydraulically to restore the line to full capacity.

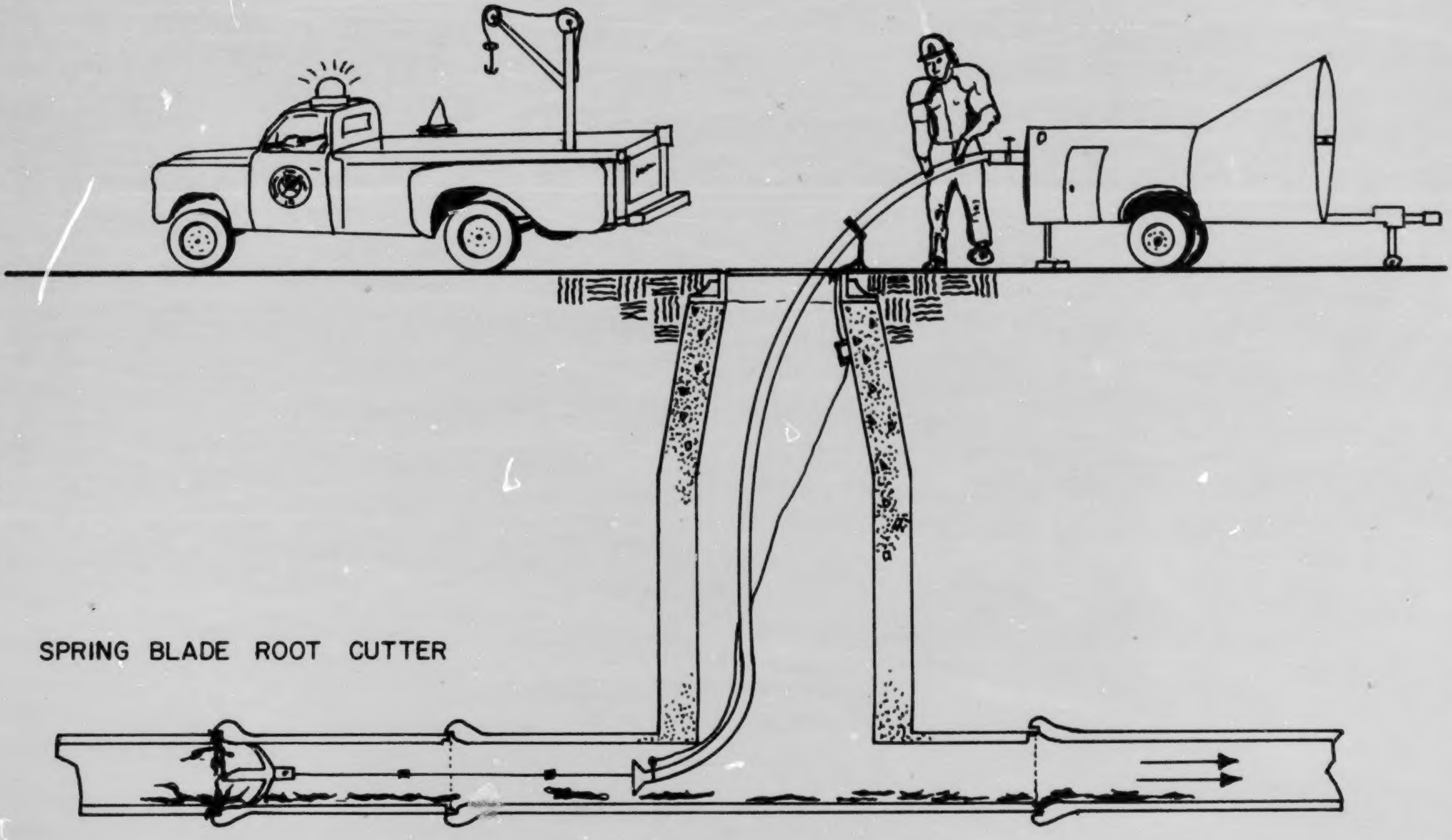

SPRING BLADE ROOT CUTTER

Fig. 5.23. Power rodder operation

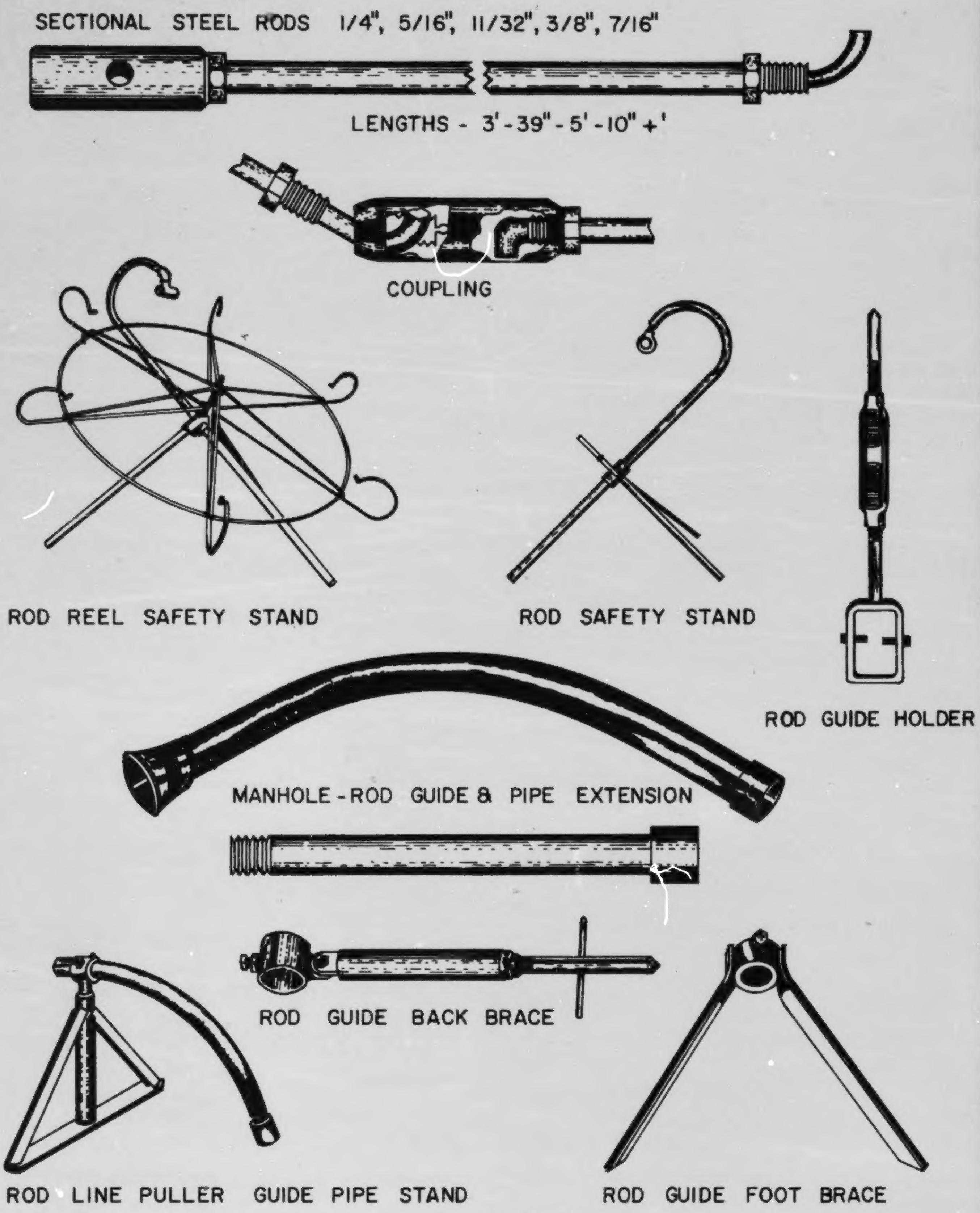

SECTIONAL STEEL RODS 1/4", 5/16", 11/32", 3/8", 7/16"
LENGTHS - 3'-39"-5'-10"+'
COUPLING
ROD REEL SAFETY STAND
ROD SAFETY STAND
ROD GUIDE HOLDER
MANHOLE-ROD GUIDE & PIPE EXTENSION
ROD GUIDE BACK BRACE
ROD LINE PULLER
GUIDE PIPE STAND
ROD GUIDE FOOT BRACE

Fig. 5.24. Power drive and hand rodding accessories

5.322 Classification

The power rodder can be classified according to several different characteristics. Basically, consideration is given for either sectional or continuous type machines. There are, however, machines which employ the use of coiled rod and are called coil rodders. These are powered by either an electric motor or gas engine. The electric unit is usually equipped with 1/2-inch coiled rod and is capable of clearing pipe sizes to 8-inches in diameter and distances of as much as 250 feet. The gas powered coil rodder is capable of clearing line sizes of 10 inches and distances of 500 feet. A one-inch coiled rod is used on these units.

The coil rod for either of these machines is available in 25 and 50-foot sections with a thread and nut coupling.

Both machines are usually trailer mounted with the trailer equipped with storage boxes for tools and other equipment.

The clearing tools used on the coil rodders, though basically designed the same as those used on the large rod machines, have a different type connection for attaching to the coil rod.

The sectional power rodder is designed to use rods put together in sections. Rod size is 5/16-inch in diameter and is available in lengths of 36, 39, and 48 inches and are put together with a double nut coupling.

The sectional machines will be equipped with a chain drive "head" for one of these lengths and only that length rod can be used.

The sectional machine, usually 9 to 12 H.P., is capable of clearing lines effectively in diameters to 12 inches and distances up to approximately 750 feet. In smaller diameter lines it may be possible to extend this to 1,000 feet, if the machine's rated capacity will allow. These distances are too long for effective clearing if the sewer contains sand or grit.

The continuous rodder is capable of holding approximately 1,000 feet of one piece continuous rod. Effectiveness decreases with the larger line sizes and consideration must be given to the capabilities of the rodding machine and equipment. Most machines are powered by a 20 H.P. gas engine and use a rod with a diameter of 3/8-inch (.375 inch), other models are available which can use rod diameters up to 1/2-inch and lengths of 2,000 feet. These larger machines are not commonly used for clearing sewers except for special applications. Generally speaking, a .375 to .395-inch diameter rod is used.

Power rodding machines can be operated by a mechanical or hydraulic drive mechanism or a combination of both. Both styles, sectional or continuous, are basic in their design and available either as truck or trailer mounted. There are some small differences in styles, but most of these differences are relative to the individual machine's operation.

Comparisons between sectional and continuous rods.

1. Continuous rodding machines are quickly and easily loaded while a sectional rodding machine requires hours to couple the sections together and tighten.

2. Sectional rods are pushed through the drive head by a positive drive, not by rollers which can slip and cause wear; however, the "drive dogs" push against the individual coupling and cause wear to the "drive dogs" and coupling. Couplings on sectional rods cause more wear on the guide hose liner than continuous rods do.

SECTIONAL
VS
CONTINUOUS

3. Continuous rodders can rod greater distances than sectional rodders can and are less apt to break at great distances.

4. Couplings and nuts on sectional rods tend to work loose and require constant inspection.

5. Continuous rodders are easier to clean than are sectional rodders. Continuous care must be given to cleaning both types of rods when they are being retrieved to prevent grit from going up the roller system.

6. When a sectional rod is broken, repair can be quickly done in the field by replacing the broken section or recoupling the rod and adding a new rod only when more footage is needed. When a continuous rod breaks, repair is difficult. One style of rod requires flat spots to be ground on the rod tip for seating set screws. Filing is not recommended because of the hardness of the rod. Another style requires a short, sharp bend at the tip to fit the coupling. Often the rod will break off before a usable bend is attained.

7. A broken continuous rod in a sewer is more difficult to retrieve since the pick-up tool does not have couplings to grab. The broken end of the continuous rod cannot be reused, and possibly the remaining portion of the rod on the machine also is lost if remaining footage is too short.

QUESTIONS

5.32A What are the uses of power rodders?

5.32B What size sewers and distances can be cleared with a sectional power rodder?

5.32C List the advantages of a sectional rod.

5.32D List the advantages of a continuous rod.

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5.323 Manpower and Equipment

Two workers are needed to properly operate the power rodder and three are recommended. One worker performs the actual operation and an assistant is needed for close observation of the action of the rod and guide hose at the working manhole. The third worker is needed to notify the operator when the clearing tool has reached its destination, or the location where it is removed, or where it is changed to a different tool. Minimum manpower requirements are:

1. Maintenance Equipment Operator

2. Maintenance Man I

If a two-worker crew has to enter a manhole, a foreman or someone else must be called to the job site so two workers will be topside when the third worker enters the manhole.

The operator should be well trained in the use and operation of the power rodder and will be responsible as well for supervision of the proper set up, safety measures and selection of the clearing tool to be used. The effective use of the selected tool will depend to a great extent upon the operator -- how well the operator determines the problem at hand and how conscientious the operator may be in getting the sewer as clear as possible.

Tools and accessories are varied, but basic in design. Many have been developed on the basis of field reports and the industry continues to produce more effective new tools and techniques.

The same tasic tools are used for either the continous or sectional power rodder. These tools include root saws, square bar augers, spring blade cutters, round or square bar corkscrews, pick-up tools, and assembly wrenches. Sketches of these tools and their uses are on the next four pages.

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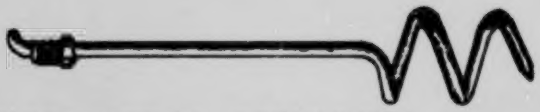
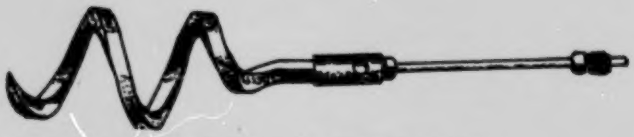
SEWER RODDING TOOLS AND USES



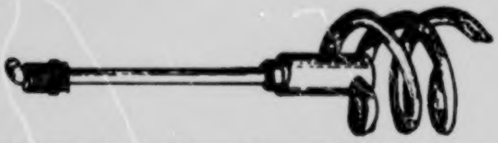
ROUND STOCK CORKSCREW

For rodding through sewers where conditions are unknown.



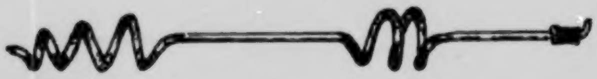
SQUARE STOCK CORKSCREW

For removing heavy root growth. Sharpened cutting edge will tear loose roots and remove other rigid obstructions when pulled backwards.



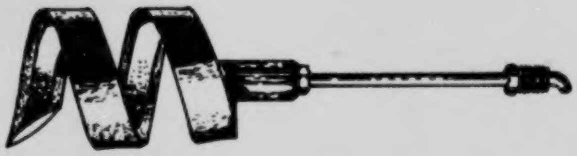
DOUBLE CORKSCREW

A double-pronged tool to remove miscellaneous obstructions.



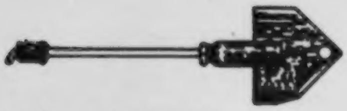
DOUBLE SAND CORKSCREW

The boring action of the corkscrew helps to pull rod through lines, impacted with sand, gravel and similar build-ups. This tool must be kept moving since it may settle into build-up material and become stuck.



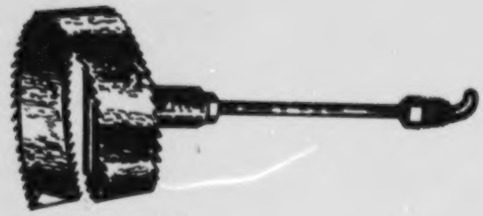
AUGER

This tool is useful in the cutting of long stringy roots and the loosening of sedimentary deposits in sewer pipe.



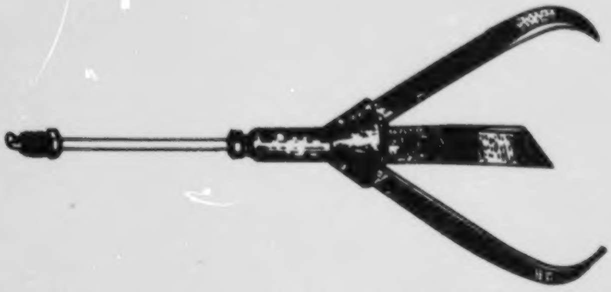
SAND LEADER

Used to guide rods across the top of build-up materials in the line by the flipping action of blades.



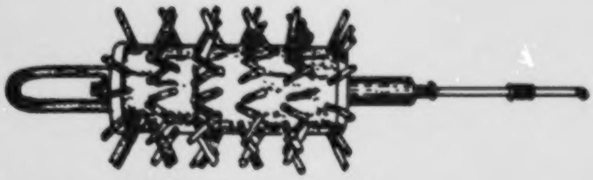
ROOT SAW

Used for power sawing of stubborn root masses in the sewer pipe.



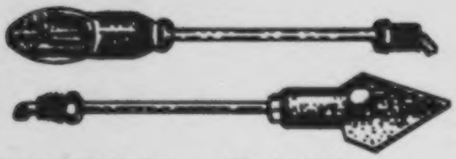
SPRING BLADE ROOT CUTTER CHUCK

This cutter with the proper size blades is used in Preventative Maintenance Type Sewer Work. Should be rotated at high speed (Power Rodder Machine) and pulled slowly through the line while rotating to effect a thorough scouring of the pipe. Note: This tool is not designed to be pushed into a sewer line.



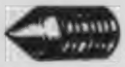
PORCUPINES

The use of turn-type porcupines is used in lines up to 12 inches in diameter and its function is to scour lines of light build-ups in conjunction with water flushing of sewer lines.



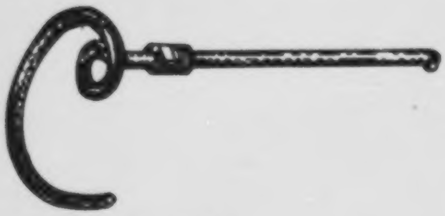
SPEARHEAD BLADES

Used in small pipes to remove hard deposits and break up hard obstruction such as glass, bottles, cans and plaster, etc.



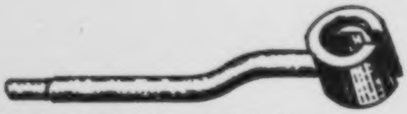
BULLET NOSE

Its designed to be screwed into end of coupler for least resistance when rodding through heavy roots, etc.



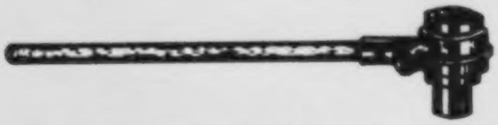
PICK-UP TOOL

Used to snare broken sectional sewer rods.



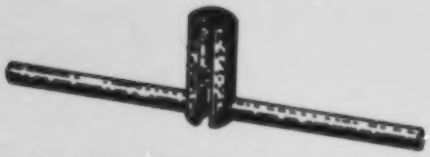
ASSEMBLY WRENCH

Used for holding and turning nuts and couplers in assembly rods and tools.



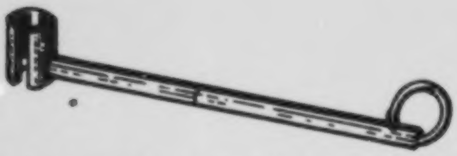
RATCHET TURNING HANDLE

Used with locking pin through pullout tool and coupler to turn rods.



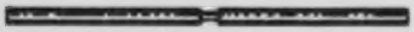
PULLOUT TOOL

Used to encircle rod coupler to push rods into or pull rods out of line.



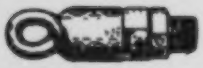
ASSEMBLY TURNING HANDLE

Used for assembling nuts and couplers for turning rods, spring loader pin engages hole in coupler.



BAR TURNING HANDLE

Used to secure into hole in coupler for turning, pushing and pulling rods.



ROD END SWIVEL

Used for pulling cables and wires through a pipe and is designed to be free turning under load at the rod end coupling.

QUESTIONS

5.32E How many workers are needed for a power rodder crew?

5.32F What must a two-worker crew do when someone has to enter a manhole?

5.32G Which clearing tool would you select to rod a pipe when conditions are unknown?

5.32H What type of tool can be used to remove grease?

5.32I Is the power rodder more effective in large or small lines?

5.324 Equipment Set Up

If a particular area or subdivision is to have roots or grease cleared with a power rodder, start at the top of the system. In so doing, any debris you may lose downstream from your work will be going into an area that you will be going to next and not into a cleared line.

Whether rodding upstream or downstream, the set up of the power rodder will be the same, except when rodding from inlets, syphons, and other similar structures. First position the machine at the manhole so the rod guide hose is pointed in the direction you will be rodding. Most collection system workers rod only from the upstream manhole when there is no stoppage. When rodding from the downstream manhole and using small tools (spearhead blade or bullet nose), these tools will occasionally turn up house service connections instead of going up the sewer.

Since most manholes are in street areas, certain safety measures must be taken for handling traffic and insuring safe conditions in manholes. See Section 4.1, Traffic and Manhole Safety, for details. Install a leader tool or smooth coupling on the end of the rod before installing the rod guide hose (Figure 5.24). This leader tool will prevent the sharp end of the rod from damaging the interior of the rod guide hose. After installing the rod guide hose, run the rod out far enough from the end of the rod guide hose to remove the guide tool and install the selected clearing tool.

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14

Pull the clearing tool back near the end of the rod guide hose. A rope will be fastened to the end of the rod guide hose and with this, insert the clearing tool into the sewer. Most power rodders are equipped with a rod guide hose brace to keep the hose from pushing back out of the sewer into the manhole when the clearing tool comes in contact with roots or other material in the system. Proper positioning of this brace is important since slack rod in the manhole can cause breakage and is extremely dangerous.

Pull the power rodder away from the manhole just enough to take the slack out of the guide hose. Often a hose-jack or brace is used to support the hose, especially when working in shallow manholes where several feet of guide hose could be left unsupported between the manhole and the power rodder. Install a sand trap or other suitable debris trap. If rodding upstream, install this trap in the downstream side of the working manhole. If rodding downstream, put it in the downstream side of the lower manhole. This will keep loosened roots, grease chunks or other material from going farther and possibly causing a stoppage.

Different models of power rodders may add to, or change this set up procedure slightly, but generally this procedure will cover the basic set up.

QUESTIONS

5.32J Should a sewer be rodded upstream or downstream from a manhole?

5.32K What is the purpose of the leader tool that is installed on the end of the rod?

5.32.L Why should a debris trap be installed on the lower side of the downstream manhole when using a power rodder?

5.325 Tool Selection and Operation

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MINEY-MOE

As mentioned before, the operator (Maintenance Equipment Operator) will be responsible for selecting the proper clearing tool. A history of the sewer you are clearing will be of great help; but lacking this information, other indications of which clearing tool to use may be grease in the manhole or trees growing close to the sewer.

If the set up is being made to clear a stoppage, a good tool to start with is the round stock corkscrew. After the stoppage has been broken loose, you should have some indication of what caused it. The next tool to use depends on whether the stoppage was caused by roots, grease, or grit.

If it is a root problem, the root saw or square bar corkscrew of correct size would be used. If grease is the problem, send the corkscrew tool to the opposite manhole, remove the corkscrew and install a cutter blade of the proper size. For heavy grit deposits, the auger will loosen these deposits. Often flushing the line while using the auger is recommended, especially if flows are low during the rodding operation.

Use of saws and cutters are preferred by some collection system workers over the use of corkscrews and augers because saws and cutters allow continuous use of the sewer instead of pulling the auger or corkscrew back each time the auger picks up a load. Rotary cutters and saws break up roots and other material and allow the material to be flushed down the sewer by the flowing wastewater.

The same set up would be used if you are trying to retrieve other clearing tools lost in the sewer.

The clearing operation is now ready to begin. One worker (Maintenance Man I) can be either stationed and protected at the opposite manhole or sent there before the clearing tool gets there. The reason is two-fold: first, to make sure you have completely rodded this section of line, and second, to remove any excess roots, or change to another tool before pulling back into the line. NEVER take hold of the clearing tool until it has stopped rotating and the power rodder is shut down. Many accidents occur because precaution is not taken here. The clearing tools are sharp and can even tangle in your clothing. A rod has a tendency to coil inside the sewer. Even though the clearing tool has stopped turning, it doesn't mean the rod cannot suddenly unwind from this torque when the tool is moved. Before making any changes or adjustments, be sure the tool is backed up from any obstructions and "uncoiled" from any twists.

Most rodders are equipped with footage meters. The operator must know where the clearing tool is at all times. If you encounter an obstruction you cannot pass and a line repair has to be made, it is essential to know where to mark out the obstructed area. The footage meter is essential too in recording footage cleared for a log or record. The time will come also when a clearing tool is lost or jammed and you cannot pull it loose. Your footage meter is most important to know where to make a "dig-up" to recover the clearing tool.

Using the proper controls of the rodder, push the rod and clearing tool into the line a few feet and slowly start rotating the rod in a clockwise direction. The speed of the rod in or out and the rotation speed depend primarily on existing conditions in the sewer and also upon the experience of the operator. If you are going into a stoppage or a known root area, particular caution should be taken. The rod travel into the sewer usually can be instantly controlled, but the rotation of the rod will cause the rod to break if it becomes lodged, and it is most difficult to stop in time unless caution and alertness are taken by the operator.

Listen to the sound of the driver and tension on the rod. Learn to recognize differences in resistance, such as when obstructions are encountered. When the sound changes suddenly, back up the rod a few feet and try again. Use the same rotation, but advance the rod slower. Look, listen and feel your way when rodding a sewer.

1. Do not jam the rod into an obstruction. This is the fastest way of breaking a tool or rod. Smooth, even operation is required.

2. Do not rotate the rod in one position for extended periods. Heat builds quickly where the rod bends in the manhole and will fatigue and break. Keep the rod moving in or out while rotating.

3. Experience will guide the operator as to the amount of torque that can be applied during the clearing operation. Generally speaking, extreme care should be taken in rotating the rod until 50 feet or more of rod is in the line.

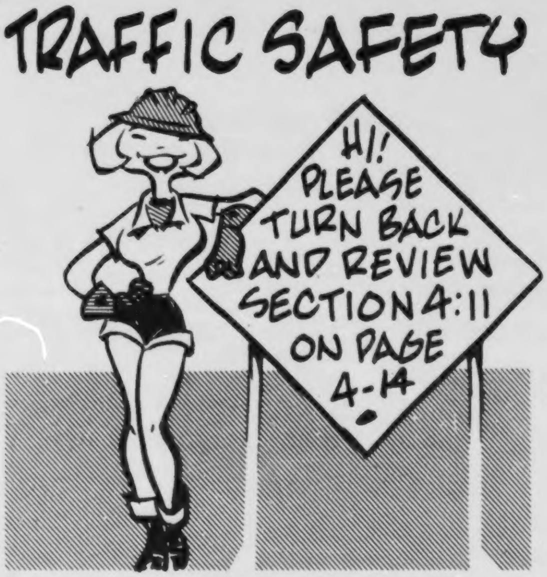
4. If the rod should break, again make sure all the torque is out of it before handling it.

After reaching the opposite manhole and the tool is not changed, usually a faster rotation on the way back will catch places missed on the way in.

Again, do not sacrifice clean lines for footage. One run may not be enough to get the sewer clear, especially with roots. The effectiveness of the clearing operation can be increased in problem areas by dumping or running water into an upstream manhole during the clearing operation. A flow in the sewer is essential for cooling the rotating tool and for flushing the sewer.

A slight variation of this procedure can be used when rodding from the upstream manhole and there are no stoppages. Send a small tool to the downstream manhole and then attach a full size tool (a root saw or spring blade root cutter if roots are a problem). This technique keeps the rod straight in the sewer by pulling on the clearing tool, instead of pushing which causes the rod to coil in the sewer. Advantages of this procedure include the application of greater pressure on partial obstructions in the sewer and increased rod life.

After completing the first section of line, remove the hose guide jack and pull the clearing tool and hose from the manhole. If debris has built up at the trap, check for gases found in sewers, ventilate manhole, and have a worker properly harnessed descend into the manhole. With the trowel or manhole scoop, clean the dislodged material out of the channel and with the bucket, remove it from the manhole and make any necessary clean up around the working area.


TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-14

If you are going to the next manhole to continue clearing, usually the rod guide hose can be left attached with the clearing tool. The power rodder often is equipped with hose hangers for this purpose, so the rod guide hose and tool are ready for the next set up. This time-saving decision is up to the machine operator and depends on the specific equipment set up because a move of some distance might tend to damage the hose. Some machines are equipped with a swivel connection for the rod guide hose so a bend is eliminated in this operation. By simply removing the tool and pulling the rod back into the machine, the hose is flexible and can be layed around and alongside the machine. This is only one of a number of time-saving short cuts which in the long run saves considerable time and wear and tear on the equipment.

QUESTIONS

5.32M How do you determine which clearing tool to use?

5.32N Which tool would you use to clear a stoppage?

5.32O After a stoppage has been cleared, which tool would you use?

5.32P What precaution should be taken before changing to another clearing tool at a manhole when the rod is still in the sewer?

5.32Q Why must you always know where the clearing tool is in the sewer?

5.32R How are the speed of the rod in or out and the rotation speed determined?

5.32S Why is water sometimes added to the opposite manhole during power rodding?

5.326 Recovery of Broken Rods

Recovery requires practically another set up procedure. How quickly you retrieve the rod depends on several factors. When a rod breaks, measure the amount of rod pulled back to determine the approximate location of the broken rod. If you are using a rodder with sectional rods, it's only a matter of removing the broken stub of a rod at the coupling and installing the pick-up tool. With a continuous rod it's more complicated because you have also lost your tool coupling with the rod. Depending on the style of rod coupling used, you will either bend a new top on the rod with a special bending tool or perhaps the style of coupling will require a flat spot or dimple in the rod for a set screw. Needless to say, extra couplings have to be handy.

Then a fishing expedition begins to try to pick up the broken piece. The pick-up tool is placed in the sewer the same as a clearing tool. Send the rod into the sewer slowly and with slow steady rotation. "Feel" your way and most often you can tell when resistance is encountered. At this point, stop rotation; and without letting the rod "unwind", pull steadily out of the sewer. The pick-up tool is so designed to screw around the lost rod and become snug. Perhaps several attempts will have to be made, but the rod must be removed, even if by dig up. If you have the clearing tool lodged, often counter-rotation of the rod reel is all that's needed to get it loose. Go in again, only more cautiously.

Rods may break in the reel section of the rodder, especially with a sectional rod. When making this repair be very careful. The rod is under some tension and can be dangerous if it gets away from you.

Use gloves and keep the end of the rod away from your face. Most accidents using power rodders involve the rod or clearing tools. Extreme care and proper instruction in attaching tools and rod repair must be followed.

There will be many different problems and a standard answer cannot be given for any specific problem. What works in one situation may not in another. Experience and observation will overcome most problems and hazards. Broken clearing tools often can be picked up with another clearing tool or perhaps flushed out, particularly if a high velocity cleaner is available.

QUESTIONS

5.32T What tool is used to recover a broken rod?

5.32U What is done if a broken rod can't be recovered with a pick-up tool?

5.327 Precautions and Safety

WARNING

NEVER HANDLE THE ROD UNDER TENSION. TREAT TWISTED RODS VERY CAREFULLY. THEY ARE **VERY DANGEROUS.**

Once again, emphasis needs to be placed on speed of rod travel and rotation. These two items combined break or twist most rods. Most machines will be capable of holding close to 1,000 feet of rod which is quite heavy. With the weight of the rod on a spinning reel, considerable twisting power is developed; but it also takes some few moments to get it stopped. An operator can get through some difficult stoppages or root problems with skill and patience.

Do not attempt to rod distances greater than from one manhole to the next unless absolutely necessary. Trying to avoid extra set up time can be much more dangerous than normal operation.

When working on a rodding crew, required procedures of operation must be established and followed for each individual. You must know your own job and the jobs of everyone else on the crew so everyone can be familiar with the over-all operation.

With constant use, rods do suffer from fatigue; and when a rod breaks, it's likely to be in the sewer. Avoid turning the rod without rod travel in the sewer. Heat builds up very quickly at any bend when the rod is turning. Therefore keep it moving at all times if possible.

Porcupine cleaning tools are available for attachment to the power rodder. Their use is not discussed because of potential safety hazards. Other tools can do a similar job in a safer manner. If a porcupine must be used, a winch and tag line must be used for safety.

5.328 Maintenance of Rods and Equipment

Sectional rods should have the rod couplings kept tight at all times. These will work loose while rodding, and a visual inspection by the operator even while working the machine will often pick up a coupling that is loose.

Make a practice of running the rod out on top of the ground on occasion and inspect the rod for bent pieces and loose couplings. When they are allowed to stay loose, the rod will wear and become weak at that point. Do not throw used couplings away - they can be reused.

Continuous rods are driven by rollers pressing on the rod. A clearing tool in the form of a clamp is furnished with the machine and has a very important function. A coarse piece of cloth or similar material is kept in the clamp tool; and when you are ready to pull the rod back into the machine, clamp this tool around the rod at the head of the machine and it will wipe the rod clean as it is returned to the reel. If this grease and grit are allowed to continue passing on into the pressure rollers, they will build up and cause wear on the rod.

Even with a clean rod, the pressure of its being rolled back and forth causes some wear. Therefore the torque on these drive rollers has to be checked and reset. Specifications for the particular machine are furnished by the manufacturer.

Always avoid sharp bends in the guide hose regardless of the type of machine. The metal liner can become bent and distorted. Inspect the guide hose frequently and carefully for wear, mounting, and mechanical damage such as crimping.

Be completely familiar with the clearing machine. Know what operating and maintenance procedures the unit requires.

Inadequate maintenance before rodding a sewer can result in considerable lost time attempting to recover a broken rod. The necessary maintenance items can easily be done on the job:

(Sectional Rodder)

1. Inspect for loose rod couplings.
2. Keep drive head chain tight.
3. Inspect for worn drive dogs and improperly adjusted belts.
4. Look for "stacking" of the rod on the reel when bringing the rod back into the reel cage.

(Continuous Rodder)

1. Maintain proper torque on the drive rollers.
2. Examine wear on the rod guide bushings.
3. Inspect for sharp teeth on drive gears. This indicates wear or needed adjustment.
4. Look for leaky hoses and fitting on hydraulic units. Maintain proper oil level in the hydraulic oil tank. Keep the hydraulic oil filter clean.

5. Fluctuating oil pressure may be due to hot hydraulic oil. This may or may not be just from continuous use. Be suspicious and check for other problems.

Always keep the rodder, tools, and accessories as clean as possible. The engine should have the maintenance and care as recommended by your shop foreman or manufacturer's directions. For more information, see Section 5.43, Rodding Machine Maintenance.

With proper maintenance and care the rodding machine will do a good job of clearing a sewer, Like any other machine it has its limitations and as experience is gained in the operation, you will know what it can or cannot do.

5.329 Records

See Section 5.18, Records.

QUESTIONS

5.32V Why must extreme care be used when handling a rod or clearing tool?

5.32W Why should a rod occasionally be run out on top of the ground?

5.32X Why should the rod be cleaned when it is returned to the reel?

5.32Y Why must everyone on a rodding crew know their own job and the jobs of everyone else on the crew?

5.32Z What maintenance should be done on the engine of the power rodder?

5.33 Hand Rods

With all of the modern equipment available, it is still necessary to have hand rods available (Figure 5.25). One of the first reasons is that hand rods can be used when and where the modern methods cannot be used effectively. Hand rods are a quick and simple answer for many stoppages. Hand rods are often used on "service request" trucks and for "off-hours" stoppage calls. They are used extensively for emergencies at nights or during weekends. After the stoppage is cleared, thorough cleaning can be done at a later date.

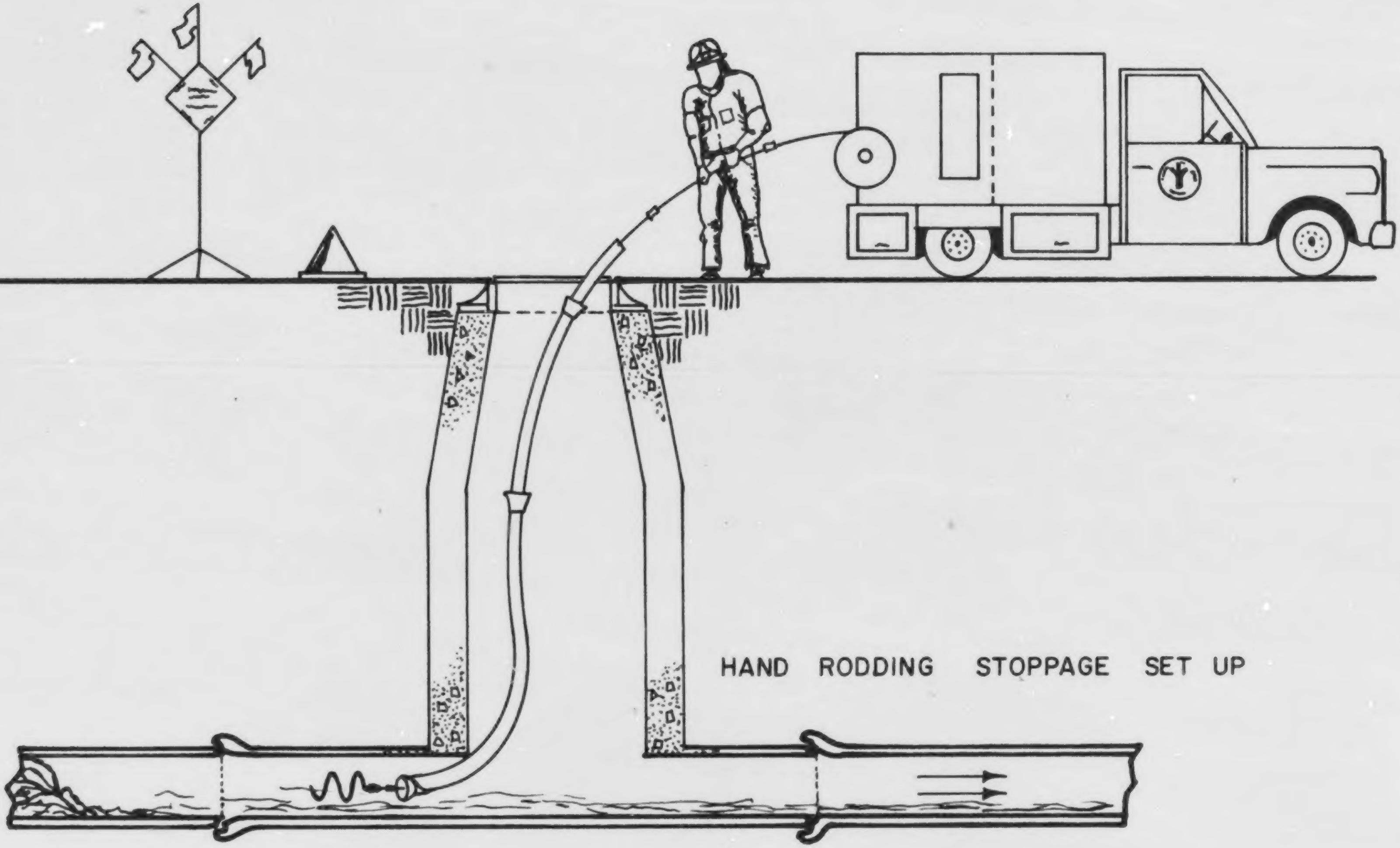

HAND RODDING STOPPAGE SET UP

Fig. 5.25. Hand rodding operation

Often maintenance crews will carry a reel of hand rod on the same work truck used in conjunction with a power rodder. If when clearing a particular area the power rodder cannot be put to use, such as an easement, the hand rod can be used and not leave a section of sewer uncleared and likely forgotten. Also a hand rod can be used from the opposite manhole to free a stuck or broken power rod.

Other maintenance crews may do only hand rodding. This is not uncommon in sanitary districts with hilly areas or in very small districts where the total length of sewer in the system does not warrant routine clearing with other types of equipment. Other factors may be involved, but the main point is the hand rod methods is here to stay at least for the foreseeable future.

5.331 Manpower and Equipment

The particular job often will dictate how many workers will be needed. However, if a crew is essentially doing only hand rodding, at least two workers are recommended.

1. Maintenance Man I

2. Maintenance Man II

A three-worker crew is required if one worker has to enter a manhole. Usually rod crews or "service request" crews consist of two workers and they never enter a manhole. If the need arises for someone to enter a manhole, a third worker must be available and added to the crew before anyone enters a manhole.

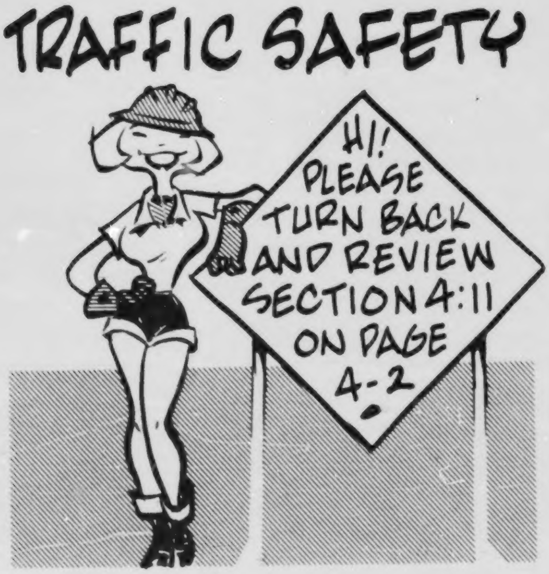
The hand rods are regular sectional rods as used on power rodders. Usually the rod length is 36-inches. This length is easy to control and simple to keep track of footage or number of sections used. The rod is stored in a shallow reel approximately four (4) feet in diameter and so constructed to keep the rod contained on the reel. It is equipped with a removable tripod which allows the reel to be set up quickly near the work site at an angle convenient for operation. When the reel is properly set up on the tripod, the rod can be pulled off or onto the reel allowing the reel to turn freely. Many work trucks are equipped with this reel fastened to the truck. When rodding is needed where the truck cannot be taken, such as an easement, sections of the rod are simply removed from the reel and pulled to the working area by hand.

Hand rod trailers are available as well that are compact and have the reel mounted at an angle convenient for use. These trailers also have a box for tools and a rack for a three-wheel, gas-powered unit to turn the rod. This power drive is essential, especially when other rodding equipment is not available or usable. The power drive has a lightweight engine with a gear reduction and control which allows the end of the rod to be attached for turning. With a hand control, rotation of the rod can be accomplished to cut roots or make penetration into stoppages very similar to the operation of large power rodders, except the distance of penetration is not as great.

Other than these basic items, reel, rod, power drive, and perhaps a trailer unit, tools would include root saws, augers, cutter blades, pick-up tool, assembly wrench, turning handle, rod guide tube and extension pipe, guide tube jack, sand traps, manhole shovel, debris bucket and hand line, and a manhole pick or hook.

5.332 Equipment Set Up

Where you are going to be set up will govern the measures for safe working conditions. Refer to Section 4.1, Traffic and Manhole Safety, for procedures to insure safe working conditions with regard to traffic routing and manhole work.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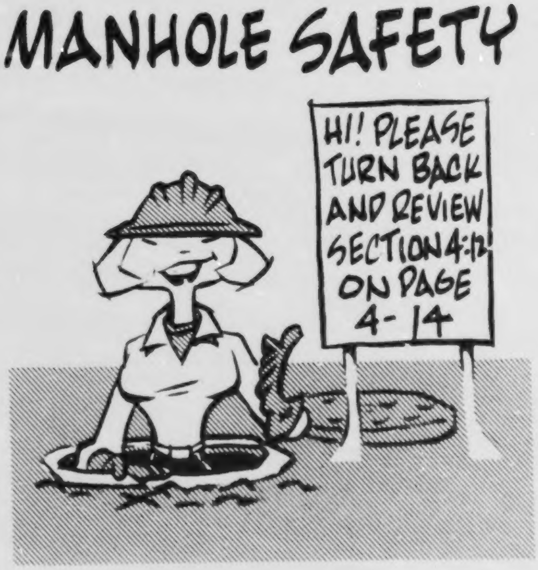
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When using a hand rod it is not uncommon to have a number of feet of bare rod exposed on top of the ground or street. Because of the nature of this method of clearing, this does occur and consideration and care must be allowed in the set up. Loose ends in a twisting operation can catch and twist and then let go with disastrous effects. Even if you are in an easement area, care must be taken not to cause damage to flowers, shrubbery, lawns, fences, and gardens with the loose rod.

Ventilate manhole and test for toxic gases, explosive gases, and oxygen level. Determine the depth of the manhole. Assemble sufficient pipe to the rod guide tube to allow the curved channel portion to firmly rest in the sewer and enough protruding above the street level to allow for working conditions, usually about 18 to 24 inches. To the exposed end attach the flared fitting through which the rod will be fed. Firmly anchor the rod guide tube to the bottom of the manhole.

Have the reel, whether truck, trailer or tripod mounted, situated several feet from the working manhole. Thread the rod through the assembled rod guide tube, install the clearing tool, then insert it into the sewer, upstream or downstream whichever method is chosen. If going upstream, install a sand trap or debris trap in the downstream manhole. If going downstream, the trap would be installed in a like manner at the lower manhole. The guide tube brace or yoke is installed to hold the tube in place at the top of the manhole. The decision to rod upstream or downstream is determined by the rodding crew in the field. Three factors are considered when trying to clear a stoppage:

1. Usually it is easier and cleaner to rod into a dry downstream manhole than an overflowing upstream manhole.

2. Try to rod the shorter distance to the stoppage. Distances are estimated on the basis of past history, good records, and on-site observations.

3. If rodding upstream, what will happen when stoppage breaks loose under a high head? If the operation is being observed properly, you can hear the flow coming and get out of the way. If rodding upstream into a stoppage with a high head behind it creates a safety hazard, rod from the upstream manhole. Always try to keep control of the rod at all times. See Section 5.334, Precautions and Safety.

Set up procedures for hand rodding vary with the different problems involved, but this procedure will fit most needs.

QUESTIONS

5.33A When are hand rods used?

5.33B How many workers are on a hand rodding crew?

5.33C Which has the greater penetration into a sewer, a hand rod or a power rod?

5.33D What precautions must be taken when a bare rod is exposed on top of the ground or street?

5.333 Operation

For routine clearing, the tool to be used at the end of the rod would depend somewhat on the sewer's condition. As with power rodding, if some history or prior knowledge of the situation is available, it takes away the guesswork. Both the square bar auger and root saw often are used for routine clearing, so one of these could be used to start clearing the sewer. If roots are suspected, perhaps it would be advisable to rotate the rod from the beginning so as not to miss any. If this method is decided upon, pull off approximately 25 feet of rod from the reel and disconnect with assembly tools (Maintenance Man I). Insert the end of this rod through the power drive unit and start rotation - one worker running the power drive (Maintenance Man I) and one worker feeding the rod into the guide tube (Maintenance Man II). When the rod is worked into the sewer, attach another 25 feet of section and repeat the operation.

Admittedly, this is a slow operation. As indicated previously, in some "hard to get at" areas or where other equipment is not available, this method is still needed.

When the clearing or rodding tool has reached the opposite manhole, the rod often can be pulled out by hand, especially if you are working upstream. If not, rotate the rod with the power drive or turning handle and pull on the rod at the same time. If sufficient space is available, long lengths may be removed at a time, but care again must be given to traffic or other hazardous conditions. If the rod can be pulled by hand, simply attach it to the rod remaining on the reel and roll it up as it is pulled from the sewer. Disassemble the guide tube brace, clearing tool, and guide tube. Clean the material from the manhole and remove the debris trap. If it is necessary for a worker to enter the manhole, the worker should be properly equipped with safety harness and hard hat. Be sure to test for gases found in sewers before entering the manhole and keep the manhole ventilated. Two workers must be topside whenever anyone enters a manhole.

Many uses of hand rods can be considered in addition to the method outlined above. One of these would be to "prove" the sewer in routine clearing. This would be to simply push the tool, auger or saw, up to the next manhole and back again without turning; if it goes by hand, fine. Otherwise, push it as far as possible by hand and then turn it only enough to get the tool through. This, of course, gets footage faster, but you may also pass up roots or other material. If this method is chosen, you can go downstream much easier than upstream.

Turning handles are often used for small trouble spots rather than using the power drive unit. If roots or other obstructions are encountered where the turning handle cannot be used, then the power drive has to be used.

To clear stoppages with a hand rod, follow a procedure similar to the one described in this operation section. Whenever possible, start at the manhole below the stoppage; and after installing a suitable debris trap, work an auger of a size smaller than the line size, up to the stoppage. If possible, hand turn auger into the stoppage with a turning handle until the rod is tight; and with torque still on the rod, pull back. This usually will dislodge a stoppage. Try to remove the dislodged material so it won't cause another stoppage downstream.

A sudden charge of wastewater will be noticeable in the working manhole when a stoppage is cleared. After this water has subsided, run the tool back and forth in the stoppage area and then pull out the rods and tool. If hand turning the rod doesn't clear the stoppage, put the gasoline driven power drive unit on the rod and use this unit. If this procedure doesn't work, try the power rodder (Section 5.32). After the stoppage has been cleared, inspect the upstream manhole to be sure the flow is normal and clean up any overflowed area.

In larger sewers the stoppage often occurs in the upstream manhole rather than in the sewer. Clear the stoppage from the downstream working manhole and then clean the upstream manhole after the water drops.

If the stoppage takes place during normal working hours, a thorough cleaning job should be done on the sewer at that time.

Procedures for clearing and set up are essentially the same for all problems where hand rods are involved. Some short cuts are used, of course, and many are not recommended mostly because safety measures are sacrificed or equipment can be damaged. Some precautions are discussed in the next section.

5.334 Precautions and Safety

One particular problem occurs all too often when hand rodding, that is, having too much loose rod unattended, or used in an unsafe method. Because it is time consuming to be continually fastening short sections of rod together, the tendency is to use a long section. If proper care and attention are given to this loose rod, a certain amount of looseness is acceptable. However, the "problem" at hand all too often takes precedence. Someone can be seriously injured and considerable property damage done should a car run over and catch hold of a loose piece of rod.

Another problem becomes evident when using the power drive unit. If too much distance is allowed between the power drive and the manhole rod guide tube, a loop can easily and suddenly be thrown in the rod and someone will be injured.

NEVER use rubber gloves while handling or guiding a rod that is turning. Even if the rod is wet, it will sieze the palm of the rubber glove and, if not stopped in time, either twist the glove from the worker's hand or cause injury. Use a manhole hook or other device to guide a turning rod.

When working a rod upstream to a stoppage, be cautious when the stoppage is broken loose. Especially if the grade of the sewer is steep. The sudden surge of stored water rushing downstream can shoot up through the rod guide tube and get someone wet.

On steep grades where a root mass has been broken loose, it is not uncommon for the water pressure to literally force the rod back out the guide tube with such force it cannot be held. In that case all you can do is control the loose rod to the best of your ability.

5.335 Records

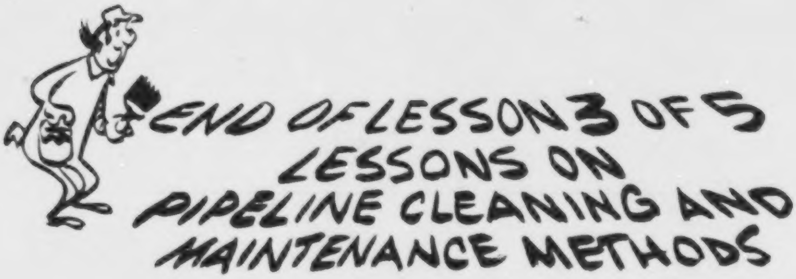
In districts where hand rodding is primarily in easements, it probably isn't done too often, especially those sewers requiring only routine maintenance. Work in these areas must be properly recorded, the same as in the troublesome areas. Emphasis has to be continually made to require systematic record keeping. All too often we keep track of the problems and let the rest go, until they too become a problem. All clearing must be properly recorded in accordance with Section 5.18, Records.

QUESTIONS

5.33E What kind of tool is used at the end of the rod?

5.33F What would you do if hand turning a rod did not clear a stoppage?

5.33G What precautions must be considered when working a rod upstream to clear a stoppage?



DISCUSSION AND REVIEW QUESTIONS

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 3 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 2.

14. Under what conditions would you use mechanical cleaning techniques?

15. Why are power bucket machines usually not scheduled on a regular basis?

16. How can you determine when a bucket is full?

17. How would you select a tool for a power rodder?

18. How is a power rodder operated in a sewer?

19. When would you use a hand rod?

541

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 4 of 5 Lessons)

5.4 CLEANING EQUIPMENT MAINTENANCE

5.41 Need for Cleaning Equipment Maintenance

Water and dirt are the two worst enemies of mechanical equipment; therefore, extra special attention must be given to sewer cleaning and inspection equipment. To do our jobs quickly and effectively, our equipment must be properly maintained and repaired at all times.

Equipment manufacturers provide the purchasers of their equipment with manuals that explain how to operate and maintain their equipment. Your job is to learn how to properly operate and maintain the equipment and be sure everyone follows these procedures. This section outlines the procedures for maintaining bucket machines, rodding machines (power rodders and hand rodders) and high velocity cleaners. The ideas presented can be applied to developing preventive maintenance procedures for balling equipment, sewer scooters, and TV inspection equipment.

5.411 Objective of Cleaning Equipment Maintenance

The objective of cleaning equipment maintenance is to keep equipment in good repair and efficiency and to help prevent equipment failure. To accomplish this objective we need tools, time, and talent.

Tools: Without the proper tools, even the best mechanic cannot do a good job even with ample time.

Time: You can have a tool box full of the proper tools and the "know-how", but we never seem to have time for preventive maintenance until it is too late and the equipment breaks down. Equipment failures are costly in terms of repair costs, hazards to workers, and working time lost by crews.

Talent: Most crews can find the "time" for preventive equipment maintenance. Try to use the talent and knowledge that comes from the manufacturer and from the experience of operating the equipment to develop and implement an effective equipment maintenance program.

5.412 Who is Responsible?

The crew foreman or the equipment operator (Maintenance Equipment Operator) is responsible for the proper maintenance of cleaning equipment. Report worn, broken or lost parts for equipment immediately so that replacements can be ordered. Regardless of your job, try to have the equipment used by the crew you work with properly maintained at all times. Your job will be easier and more enjoyable if you are not always fighting with equipment that doesn't operate properly or is always broken.

QUESTIONS

5.4A Why must cleaning equipment be properly maintained at all times?

5.4B How can a worker learn how to maintain cleaning equipment?

5.4C What is the objective of cleaning equipment maintenance?

5.4D What are the three essential factors for an effective equipment preventive maintenance program?

5.4E Who is responsible for the equipment maintenance program?

5.42 Bucket Machine Maintenance

Bucket machine clearing procedures require special care of the equipment. Break down and failure of equipment often results in costly repairs.

5.421 Maintenance Tools

Considerable time and effort can be saved if enough tools are kept on the job for crews at both the upstream and downstream manholes. Often these crews are a considerable distance apart, especially when working in easements because some manholes may not be accessible in backyards.

Necessary tools include pipe wrenches, crescent wrenches, pliers, screwdrivers, Allen wrenches, hack saw, chisel, hammer, cable cutter, extra oil squirt can, grease gun, wire brush, extra cable clamps, clevis, pins and wiping rags.

5.422 Maintenance Procedures

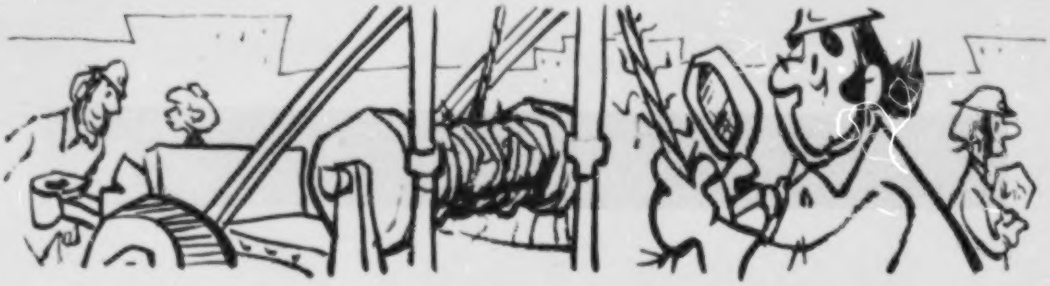
The following tasks must be done regularly or when indicated for effective bucket machine maintenance.

1. Keep cable scroll and level wind system (Figure 5.26) well oiled. The number one problem is lack of proper lubrication.

2. Keep oil or grease cups full and chains lubed.

3. Inspect belt tension, chain tension, and gear clearance. NOTE: Record any wear on spur gears (Figure 5.27).

4. Lube spindles of lower rollers often, especially if they are in contact with water. Make sure they have clearance and turn properly so the cable doesn't slide and cut grooves.



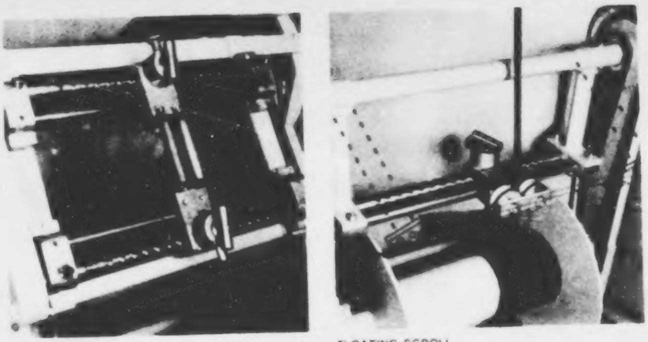
5. Watch for loose cable clamps and frayed cable. Tighten all cable clamps at the start of each day.

6. Look for loose rivets on buckets, badly worn bails and clevis eyes. Turn these into the shop for hard-facing and repair.

7. Keep pipe threads clean and oiled on extension pipes. Keep extra couplings on exposed pipe thread.

8. Keep stabilizer legs in good operating condition. If a bind starts, get it straightened now!

9. Keep legs locked "up" when traveling.



DUAL SCROLL

FLOATING SCROLL

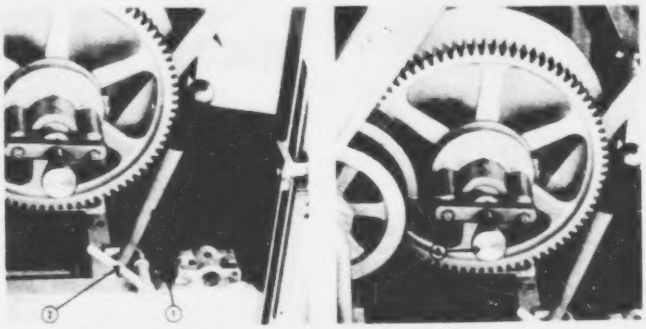
DUAL SCROLL (Truck-Loders)

Heavily reinforced dual scroll features two synchronized scrolls and follow dogs giving a firm, steady guide to properly wrap the cable on main cable drum.

FLOATING SCROLL (Pull-in Machines)

Hinged floating scroll with roller guides compensates for each wrap of cable on the cable drum. Keeps cable in a direct line from upper cable sheave through level wind to cable drum.

Fig. 5.26. Cable scroll and level wind system
(Courtesy of Municipal & Utility Division, Rockwell International)



SAFETY BOOSTER CLUTCH

SURE-LOCK CLUTCH

SAFETY BOOSTER CLUTCH

The safety operating lever (#1) controls bucket travel. At point (#2), tension is held on the operating lever at a predetermined speed of bucket travel. The tension is adjustable, and under overload conditions the belts will slip, thus protecting pipe and machine.

SURE-LOCK CLUTCH

Positive engagement of the bull gear drive to the cable drum is accomplished by means of two heavy hardened pins which lock into two sleeved, hardened holes in the bull gear. A slight pull and twist on the knob (#3) disengages the gear; a reverse twist re-engages.

Fig. 5.27. Bucket machine spur gears
(Courtesy of Municipal & Utility Division, Rockwell International)

QUESTIONS

5.4F Why should bucket machine crews have enough tools for crews at both upstream and downstream manholes?

5.4G What is the number one maintenance problem with the cable scroll and level wind system?

5.4H When should cable clamps be tightened?

5.4I What should be done when a bend is observed in a stabilizer leg?

5.43 Rodding Machine Maintenance

Preventive maintenance for all rodding machines is similar, but some aspects depend on the type of machine. Maintenance procedures are outlined in this section for sectional and continuous rodders and hydraulic units. Be sure to read and understand the equipment manufacturer's instructions and follow them.

5.431 Maintenance Tools

Some of the tools used to maintain rodding machines include assembly wrenches, crescent wrenches, Allen wrenches, screwdrivers, pliers, hack saw, file, oil, squirt can, grease gun and wiping rags.

5.432 Sectional Rodder

1. Daily.
    a. Inspect tension of drive head chain. Tension must be tight. Why? If loose, drive dogs tend to ride up and over rod couplings.
        1) Make sure chain track clearance is not too great.
        2) DO NOT turn adjusting turn-buckle without loosening bearing plate.
    b. Inspect wear of drive dogs. Why? If badly cupped, rod coupling will tend to hang up.

2. Inspect

   a. Belt tension and wear.

   b. Vari-speed control.

   c. Drive chains to sprockets.

3. Forward - Reverse Transmission (Snow-Nabst)

   a. Oil level (machine oil only as specified by manufacturer, not motor oil).

   b. Firm IN-OUT, without drive head creeping.

   When adjusting remember that if equipment has cast iron bands inside, they will break easily. Some equipment has a cast iron guide ring or support instead of a band.

4. Tight Rod Couplings

   a. Visual inspection while in operation. Stop operation and tighten as necessary.

   b. Periodically inspect all rod couplings. Get rid of those that are severely worn or damaged and save the rest for reuse.

5. Stacking of rod on reel.

   Visual inspection by operator when returning rod to reel.

   a. Proper adjustment of rod guide tube and rollers prevents jamming or couplings catching on travel out.

   b. Wear on funnel of rotating guide tube.

OPERATOR PREPARING FOR VISUAL INSPECTION

    c. Wear on tube rollers.

6. Brake band or disc brake blocks.

    a. Inspect for wear.

    b. Replace before rivets cause drum damage.

7. Rod hose guides.

    a. Do not shove rod out without at least a coupling on the end, preferably a bullet tool.

    b. Keep slack out of hose guide when working shallow manholes.

5.433 Continuous Rodder

1. Proper torque on the drive rollers frequently depends on rod wear. Inspect for slippage while in use. Adjust torque when needed or wear will be excessive on rod and rollers. Also performance of rodder will be poor.

2. If combination with gears for drive head.

    a. Tooth clearance of gears.

    b. Sharp or pointed teeth.

    c. Worn gear bushings.

    d. Broken gears.

    e. Slack on reverse.

    f. Gear chatter.

3. Wear of rod guide bushings. Worn bushings tend to shave the rod.

4. Keep rod clearing tool in use, replace pads often. Grit combined with grease tend to shorten rod life.

5.434 Hydraulic Unit on Rodding Machine

1. Look for and repair leaky fittings and hoses.
2. Keep oil filter clean (some filters have a warning type gauge).
3. Maintain proper hydraulic oil level (this is particularly important in hot weather).
4. Replace cracked, chafed, or worn hoses.

For more information, see Section 5.328, Maintenance of Rods and Equipment.

QUESTIONS

5.4J Why must the tension on the drive head chain of a sectional rodder be tight?

5.4K What does the torque on the drive rollers of a continuous rodder depend on?

5.4L Hydraulic units require what maintenance?

5.44 High Velocity Cleaner Maintenance

To properly operate and maintain a high velocity cleaner, the operator must be completely familiar with all aspects of the unit. Read and understand the manufacturer's instructions for proper maintenance procedures.

5.441 Maintenance Tools

Tools should include pipe wrench, large crescent wrench, grease gun (special grease recommended for pressure swivel), screwdriver, a good grade of plastic tape, plus other hand tools found in a well equipped tool box.

Special tools needed to maintain the pressure pumps are provided by the manufacturer.

5.442 Continuous Considerations

Whenever you are operating a high velocity cleaner, always be alert for:

1. Odd or suspicious sounds from:
    a. Intake valve seats
    b. Relief valve leaking (squeal)
    c. Belt slippage
2. Higher or lower than usual RPM to maintain pressure. May be caused by:
    a. Intake valve partially closed
    b. Air leaking into system
    c. Plugged orifice[6] in cleaning nozzle
    d. Belts slipping
    e. Faulty by-pass pressure valve
3. Sluggish reel return. May be caused by:
    a. Low hydraulic oil supply
    b. Filter needs replacing
    c. External or internal leak in a hydraulic control
    d. Foreign particles in the directional valve. (Filter should catch particles.)

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[6] Orifice (OR-i-fiss). An opening in a plate, wall or partition.

5.443 Daily

1. Keep all equipment and accessories clean.
    a. Tool compartments.
    b. Engine compartment
        1) Wipe up oil and grease
        2) Paint rust spots when they appear
2. Hold Tank
    a. Drain to prevent
        1) Rust
        2) Sand or dirt deposits. Always flush hydrants briefly before filling tank.
    b. Clean tank strainers
3. Oil Levels
    a. Engine
    b. Pressure pump
    c. Hydraulic-oil tank
4. Inspect belt tension and packing glands. (See Chapter 8, Equipment Maintenance, Section 8.3, Pumps)
5. Lube drive chains and water pressure swivel.
6. Tape splits in hose.
7. Look for worn or plugged orifices in nozzle.
8. Inspect nozzle carrier. Nozzle carrier keeps nozzle off bottom of pipe.

5.444 Cold Weather Maintenance

1. Drain pump daily. Use air pressure to drain pump if necessary.
2. Cover rear canopy openings. A small electric heater will help keep equipment from freezing.

5.45 Equipment Engines

Equipment engines require special attention so they will operate when needed. Develop a regular maintenance program and follow manufacturer's recommendations. The items listed below are important considerations for proper care of engines used to operate cleaning equipment.

1. Always be sure oil and water levels are in proper range BEFORE starting unit.
2. Use a fresh supply of the proper grade of clean gasoline.
3. Change oil and air filters according to manufacturer's recommendations.
4. Exercise (operate) equipment weekly if not used.
5. Use proper type of oil in engines, transmission and for lubrication.
6. Keep battery terminals clean and battery charged for engines with electric starters, especially during winter months.

QUESTIONS

5.4M Why must the operator of a high velocity cleaner be completely familiar with the unit?

5.4N When operating a high velocity cleaner, you should always be alert for what kinds of problems?

5.4O What oil levels should be checked daily?

5.4P What items must be considered during cold weather maintenance of high velocity cleaners?

END OF LESSON 4 OF 5 LESSONS
ON
PIPE CLEANING
AND MAINTAINANCE METHODS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 4 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 3.

20. Why should pipeline cleaning equipment be maintained?

21. How would you maintain pipeline cleaning equipment?

22. What maintenance items should be considered continuous when you are operating a high velocity cleaner?

23. How would you maintain equipment motors used to operate cleaning equipment?

555

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 5 of 5 Lessons)

by Walt Driggs and John Brady

5.5 CHEMICALS

5.51 Uses of Chemicals

Chemicals can be very helpful aids for cleaning and maintaining wastewater collection systems (Figure 5.28). Proper application of effective chemicals can be used to control roots, grease, odors, concrete corrosion, rodents, and insects. The purpose of this section is to indicate how to determine if chemicals might be effective and how to select, apply and evaluate the effectiveness of chemicals. Where specific chemicals are mentioned, trade names are provided solely for illustrative purposes.

5.52 How to Select Chemicals

5.521 Words of Caution

Many people are reluctant to try chemicals because of past unfortunate experiences involving exaggerated claims. Did you ever hear the story about the salesman selling a caustic and aluminum shaving compound? He claimed his chemical would unplug stoppages. The question was asked, "What will this chemical do to roots?" He replied, "When you pour this chemical into a manhole, it starts to boil and churn. The aluminum shavings will move so fast they will cut the roots off at the edge of the pipe." This is an example of a false claim.

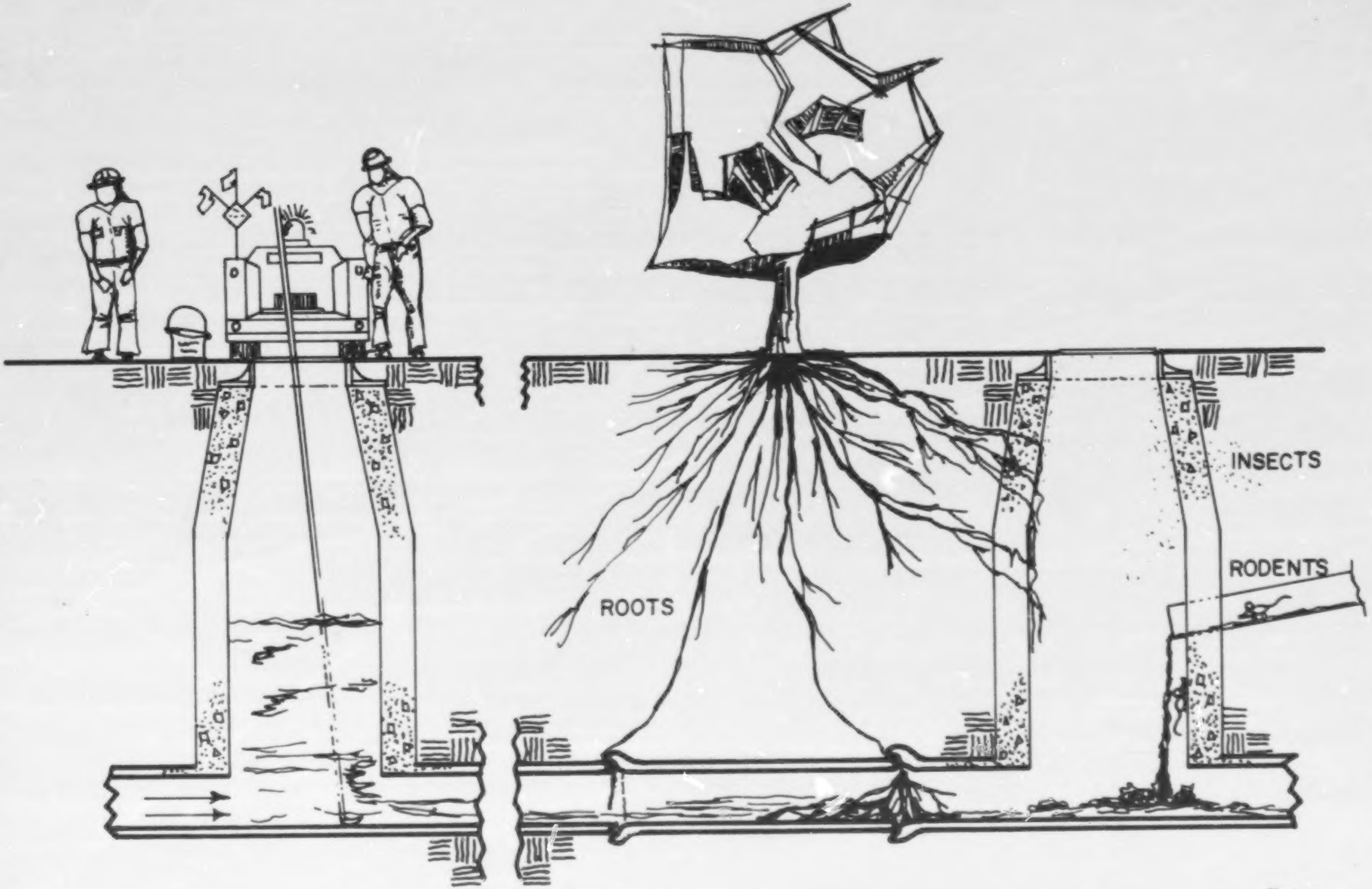
ROOTS
INSECTS
RODENTS

Fig. 5.28. Chemical operation

Look out for exagerated claims by promoters. No chemical will stop odors, remove roots, or repair breaks in sewers. Some chemicals may cause more damages than benefits. For example, you may clear a kitchen drain trap with a half a cup of chemical. To clear a similar stoppage in a 36-inch sewer would require tons of chemicals. This procedure would be very expensive and could cause extreme hazards downstream.

Two very important factors must be remembered when evaluating and using chemicals:

1. Chemicals will not clear stoppages or blockages in sewer mains. Be wary of any chemical that makes this claim. How does the chemical move 100, 200 or 300 feet down a plugged sewer to the stoppage at the proper concentration?

2. Laboratory or "desk top" demonstrations work because chemical concentrations are adequate for the amount of water involved. Apply these concentrations in the field and the volume of water in a sewer could require a large amount of costly chemicals to achieve the required concentration at the proper location. Ask your chemical supplier to calculate the exact amounts of chemicals needed to provide the desired chemical concentrations. For example, how much chemical is necessary to produce effective heat ranges in the sewer to dissolve grease or burn roots?

Don't get trapped into thinking you will at least be doing something if you buy a chemical. Very often you are merely contributing to the promoter's income, but not helping your situation. Contact water pollution control regulatory agency officials before using a chemical. Some chemicals are banned, while others are approved for appropriate use.

5.522 A Selection Procedure

Ideally chemicals you wish to use have been tested by a respectable laboratory and the results are favorable. Many universities, states, federal agencies and private testing laboratories conduct impartial tests of new chemicals before they are sold. For assistance and guidance regarding the application of chemicals to your particular problem, contact the U. S. Environmental Protection Agency, state water pollution control agencies and professional associations for recommendations. If a chemical has not been tested to your satisfaction, don't buy it.

All chemicals of the herbicide, insecticide, fungicide or rodenticide type require registration under the U. S. Environmental Protection Agency, Pesticides Regulation Division. These chemicals must have an approval number issued by EPA before use to prevent harmful contamination of a water course.

If a chemical does not require an EPA approval number and is untested, attempt to have a recognized laboratory perform the necessary tests. Otherwise, you must design your own testing program or risk throwing your agency's funds down the sewer.

WARNING

Never put any chemicals containing metal chips or filings into a sewer. This material will most likely settle out in the sewer without reacting or, if it does react, will produce hydrogen gas. Hydrogen gas increases the possibility of an explosive atmosphere developing in the sewer.

Here are some steps to follow if you must develop your own chemical testing program that are fair to your agency and the chemical company:

1. Ask the salesman to provide documentation of his claims in writing. Realize that he will only provide you with favorable results. A telephone call to the worker who used the chemicals will reveal if the chemicals are still being used successfully and if the costs are reasonable. Phone calls provide the opportunity for you to ask questions and also to obtain information people might be reluctant to put in writing.

2. Calculate the cost per foot of sewer to be treated before buying and applying the chemical. Costs may be too high even if the chemical works as claimed.

3. Work with the salesman to select a segment of sewer to serve as a test section (at least between two or more manholes). Develop a procedure for evaluating the effectiveness of the chemicals in the test section over a period of time recommended by the salesman. If the salesman refuses to demonstrate his product without charge and with an authoritative evaluation other than his own - BE VERY CAUTIOUS.

4. Take photographs or video tape the existing problems in a test section of sewer BEFORE the chemicals are applied.

5. Agree in writing with the salesman the results that should be produced by the chemicals and the method of payment for the chemicals. Determine payment on the basis of effectiveness of chemicals.

6. Apply chemicals as directed under the supervision of the salesman. Recalculate and verify dosage rates applied.

7. Retelevise and photograph or video tape the treated test section of sewer in accordance with your agreement with the salesman.

8. Be sure to keep good records before, during and after testing.

9. If the chemicals worked as claimed or agreed upon, pay the bill. If the chemicals did not work and there were no agreements regarding partial payments for partial effectiveness, then don't pay. No work, no pay.

10. Be wary of companies that offer a "money back guarantee". How do you get your money back if you are not satisfied? What happens if the company goes bankrupt? A reputable company with a good credit rating and bank references may be worth the risk.

11. Sometimes the selection of a "control" sewer may be helpful. No chemicals are applied to problems such as roots in this sewer. The purpose of this line is to provide a means of comparing problem development such as root growth in lines with and without chemicals.

If your agency is too small or without the resources to conduct an extensive testing and evaluation program as outlined in this section, try to use as many of the concepts discussed as possible to protect your agency.

Any company not willing to stand behind their products and subject them to an agreed upon evaluation, does not deserve to use your valuable time trying to sell you questionable products. When your agency has a firm policy regarding the testing of chemicals before purchase, the effectiveness of your chemical program will be greatly improved.

QUESTIONS

5.5A Chemicals can be used to control what types of problems in wastewater collection systems?

5.5B Why are some people reluctant to use chemicals to solve sewer problems?

5.5C Why might doing nothing be better than trying an untested chemical?

5.5D Why should metal chips or filings not be put into a sewer?

5.5E What precautions should be taken before developing a testing program?

5.53 Roots

5.531 Causes of Root Problems

Let's try to understand how to approach the cure for roots in your wastewater collection system by learning the causes of root problems.

One city in the United States had a serious problem. The residents were complaining about the high rate of stoppages in the wastewater collection system, the flooding of their homes, and the high costs they were having to pay to replace their home service lines.

The city council at one of their meetings discussed the complaints, heard the city manager tell of the high cost of keeping the flow within the pipe, and decided there was one simple answer to this problem - let a contract for the removal of all the trees in the rear easements (estimated cost of removal - $300,000) and pass an ordinance that would prohibit any replanting.

The next city council meeting was attended by almost the entire town. The public told the city council that they were not going to give up the shade in their side and rear yards. "There must be a way to keep our shade trees that have increased the value of our property and made our rear yards a beautiful place to enjoy and also to keep wastewater flowing in the collection system," commented one city resident. Somehow shade trees and wastewater collection systems sewers must be able to occupy the same easement.[7]

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[7] Good planning might have placed the wastewater collection system in the street depending on distances, costs, and service requirements. This would not have prevented problems caused by roots, but would have placed the sewer lines a greater distance from trees planted in front yards than from trees in back yards if the sewer was in the back yard. Usually fewer trees are planted in front yards than back yards.

The remedy or cure for roots was not as simple as the city council had thought, or did they just try the most obvious and not try to seek the right cure for the problem of roots?

We are going to learn more about root control, but first we should try to understand the causes of root problems.

Let's think of the farmer of 1900 and some of the ways he combatted weeds in his field. He hoed and disced and some of the more progressive farmers were starting to treat the soil with chemicals that would control the weeds and allow the crops to flourish. Effective use of the proper chemicals on roots can help avoid a lot of hard work today.

Figure 5.29 shows roots hanging down from the top of a sewer pipe. This type of root growth is either new root intrusion or old root intrusion that has been pruned. If you have ever pruned a tree, you know that after each pruning the tree develops new growth just below each cut.

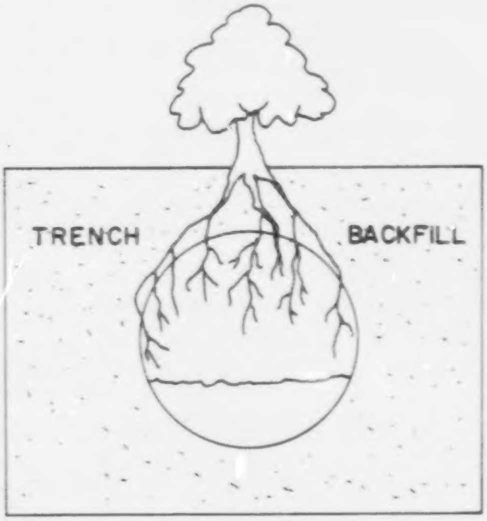

Fig. 5.29. Roots in a sewer pipe

What happens when roots are pruned or cut in a sewer line? The roots in the sewer line will grow similar to the limbs of a tree; thus after each pruning they will send out new growth just back from the cutting. Each time a root is cut, it will add new growth laterally, but also it will increase in diameter. When roots increase in diameter, serious problems develop that in time will break the pipe or open up the joint even more (Figure 5.30).

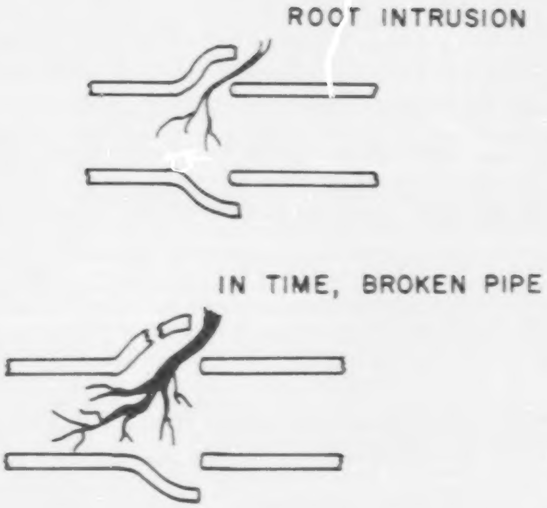

Fig. 5.30. Root breaking pipe

5.532 Information Needed From Vendor or Manufacturer

When you are starting a chemical program for root control, the following information must be obtained from the manufacturer:

1. Recommended herbicide or herbicides and EPA approval number. Verify information with EPA and other regulatory agencies because rulings sometimes change when new experience is gained.
2. Recommended method of application such as flooding, spraying or foam. Sometimes the application of a combination of two herbicides is more effective than only one herbicide.
3. Concentration of chemical and amount required to treat a selected sewer line. Also learn the correct way of determining the specified concentration for other sizes and lengths of sewers for future reference.
4. Time of contact of chemical with roots, or time required for the sewer to be flooded or blocked with chemical to achieve root kill.
5. Preferred meteorological conditions at time of application. Rates of herbicide uptake through roots are largely determined by rates of plant transpiration or water loss from the leaves of the plant.
6. Cost for chemicals and application, including labor and equipment.
7. Hazards to wastewater collection system workers working downstream from section where chemicals will be applied.
8. Effects upon the downstream wastewater treatment plant by the use of the chemical.
9. Effects on receiving waters of wastewater treatment plant effluent.

5.533 Application (flooding, spraying and foaming)

This is the area where many chemicals fail to perform to the manufacturer's claims and make many maintenance people leary of new chemical products. If specific claims are made as to results to be expected, then the chemical manufacturer should be willing and able to provide specific instructions as to method of application, concentration of chemical, and required contact time. Directions for the application of some chemicals suggest that you "dump one can of chemicals in the sewer and if that doesn't work, dump in another can." Haphazard instructions of this type will usually produce haphazard results.

To apply a chemical to control roots, first televise the section to be treated to determine existing conditions. When ready to apply the chemicals, isolate the system to be treated by plugging the upper and lower ends of the sewer line to be treated (usually a segment of line between manholes). Mix the chemicals according to manufacturer's directions and safety precautions, and slowly meter the chemicals into the test section of line. If the line is to be flooded, allow the mixture of water and chemical to fill the sewer and manhole to a level three to six inches above the top of the sewer pipe in the upstream manhole. Leave the line plugged and the chemicals in the line for the specified contact time. Maintain constant observation of the system above the plug to prevent flooding of a home or business. Flooding sewers to treat roots can only be done in low flow sewers. Otherwise, a by-pass pumping and piping system may have to be devised and installed.

One method of reducing chemical cost is to reuse the chemicals in downstream sections of the sewer. Plug the lower sections of the line and allow the chemicals to flow downstream to the next section of line requiring treatment.

A small addition of chemicals may be necessary to maintain the desired concentration. Some dilution of the original chemical batch usually occurs when the chemical slug flows down to the next test section.

Another method of recycling used chemicals is to pump the chemicals from the test section into a tank and reapply them in another section. Some additional chemicals may have to be added to maintain the desired dosage in the next test section. Depending on the chemical used, be sure to follow manufacturer's recommendations regarding safe handling of chemicals at all times.

Infiltration of water into the sewer line may be expected to wash the chemicals off the roots and decrease the effectiveness of root kills. Treatment of roots during periods when infiltration rates are low usually is more effective.

5.534 Evaluation

Root control by chemicals is not as fast as removing roots by cutting them off with a power rodder, but chemical control is more permanent. Effective chemicals can control roots in a sewer for as long as two to five years.

To evaluate the effectiveness of a chemical root control program, televise test and control sections one week, one month and three months after treatment to evaluate the effectiveness of the chemicals. With proper chemicals and application, root control by the use of effective chemicals is a very desirable preventive maintenance program and is cost effective.

5.535 Safety Precautions

Before using any chemicals make sure the field crew has thoroughly read the label on the chemical container and understands the type of chemical, reactions that will occur, safety measures for handling and applying, equipment used for mixing and application, action to be taken if the chemical is spilled or splashed on workers or materials, and clean up. Action in case of an accident includes first aid treatment to be given and how to inform a doctor of the exact chemical compounds involved if a person needs medical aid so the doctor will know how to neutralize the chemical and properly treat the victim.

When handling or mixing any chemical, always wear rubber gloves, an apron, goggles or a face mask for protection. Do not enter manholes without proper precautions (Chapter 4, Section 4.1, Traffic and Manhole Safety). Spillage of root control chemicals on lawns or gardens will kill plants and sterilize soils for long periods of time.

WARNING

1. Do not mix unknown chemicals.
2. Do not add a strong acid or alkali (base) to a chemical unless instructed to mix the chemicals.

5.536 Other Methods of Root Control

This section has emphasized the control of roots in sewers by the use of chemicals. There are other methods of root control.

First, the best way to control roots is to install sewers that don't leak. Modern pipe materials and joints can be installed without leaks so roots can't enter a sewer. In older sewers where there is the potential for root intrusion, methods of root control include:

1. Eliminating deep rooted trees.
2. Inserting a liner in the sewer (Chapter 6, Section 6.7, Polyethylene Pipe Lining).
3. Not allowing trees to be planted over sewers.
4. Removing roots and sealing sewer (Chapter 6, Section 6.8, Polymeric Sealing).
5. Frequent clearing of roots from sewer.

5.537 Additional Reading

An excellent paper on the evaluation of chemicals for root control is "Chemical Control of Tree Roots in Sewer Lines," by John F. Ahrens, Oliver A. Leonard, and Neal R. Townley in Journal of Water Pollution Control Federation, Volume 42, Number 9, pp. 1643-1655 (September 1970).

QUESTIONS

5.5F What happens when roots in a sewer are cut?

5.5G What information must be obtained from the manufacturer before starting a chemical program for root control?

5.5H How can chemicals be applied for root control?

5.5I How can homes or businesses become flooded during a chemical operation?

5.5J How can chemicals used for root control be recovered and recycled?

5.5K What safety precautions should be used when chemically treating roots?

5.54 Grease

Grease and soap problems used to be confined to sewer lines that served restaurants or industrial dischargers. These materials were controlled to some degree by grease traps or grease interceptors.

With the widespread use of home garbage disposal units, the problem has now spread throughout the collection system.

Problems commonly develop when greases, oils and soaps cool and solidify and form a coating or deposit on the walls of a sewer. The rate of build up of a grease deposit depends on the amount of grease carried by the wastewater, the flow and velocity of the wastewater, and the size of the sewer. If the sewer changes slopes (steep to flat), intersects with another sewer, or has dips or other alignment irregularities, then these factors can encourage the development of grease deposits. Sewers larger than 18 inches in diameter tend to have fewer grease problems than smaller sewers because they usually flow more than half full with velocities high enough to prevent the build up of grease.

Most uniform building codes or sewer-use ordinances require commercial and industrial dischargers to install grease traps or grease interceptors if grease is in their wastewater discharges. These units are similar to a septic tank and are designed to allow floatables (greases, oils and soaps) to accumulate on the surface and heavy solids to settle to the bottom. The floatables and solids must be removed on a regular basis.

Responsibility for cleaning and maintaining grease traps and grease interceptors depends on community policy, but usually it is the responsibility of the discharger. Unfortunately many dischargers do not know how to or do not bother to properly clean and maintain grease traps and grease interceptors. Some industries do an excellent job because contents of the traps can reveal that problems have developed in their industrial processes that are causing a loss of profits and also causing an increase sewer-use billing.

Grease traps and interceptors must be thoroughly cleaned. Merely pumping the liquid out of the trap or interceptor does not remove the grease or solids. Frequency of cleaning may vary from twice a month to once every six months, depending on the amount of grease in the wastewater and flow conditions.

Field evaluations of grease traps and grease interceptors have revealed that usually they are undesirable and ineffective for the following reasons:

1. Dischargers (such as restaurants) do not properly clean and maintain the facilities.

2. In spite of the installation and maintenance of the facilities, grease problems still develop in smaller sewers. Problems develop because the facility is too small, improperly maintained, or the wastewater temperature was so high that the grease did not solidify until it reached the sewer.

3. Undesirable side effects are produced by grease traps and interceptors in the collection system and the wastewater treatment plant.

    a. Solids deposited on the bottom of the trap or interceptor start to decompose. This decomposition produces odors in the collection system, exerts a greater load on the wastewater treatment plant, and increases the sewer-use charges.

    b. Decomposing material from the trap or interceptor can flow into the wastewater collection system and increase the production of hydrogen sulfide (see Section 5.6, Hydrogen Sulfide Control).

    c. When the trap or interceptor is cleaned, a large mass of undesirable material must be disposed of in a sanitary landfill.

In summary, we may be better off without grease traps and grease interceptors, because without them grease gets into the sewer where collection system workers have the knowledge and equipment to handle grease problems better than anyone else. The ultimate solution to grease problems is to educate the sewer users that grease, oil, fat and soap should not be discharged into the sewer. These materials should be separated, salvaged and recycled if possible like aluminum cans and waste papers.

Effective grease and soap control with methods available to the collection system maintenance worker include the high velocity cleaner, hydraulic balling and power rodding. Many chemicals have been sold in the past and are being sold today to control grease and soap in sewers. These chemicals are sold as bio-acids, digesters, enzymes, bacteria cultures, catalysts, caustics, hydroxides and neutralizers. Many of the compounds are claimed to control odors, remove grease, eliminate roots and accelerate activity in biological treatment processes in treatment plants. By scanning any trade journal, you can easily develop an extensive list of these products. Many have their proper use in specific locations under specified conditions.

Careful evaluation of the results produced by these chemicals should be made in comparison with mechanical and hydraulic cleaning methods used for sewer line maintenance. The ideal control of many troublesome materials is at the source by educating the public that grease, oils, coffee grounds and eggshells should be disposed of in the garbage can along with paper, tin cans and plastic containers. This practice would eliminate some of the homeowners' plumbing problems and make the job of the collection system and treatment plant workers much easier. The only recommendation we offer regarding these types of chemicals is to develop a stringent evaluation program to test these products as outlined in Section 5.522.

5.55 Odors

Odors have long been associated with collection system and wastewater treatment plants and are primarily caused by the production of hydrogen sulfide (Section 5.6, Hydrogen Sulfide Control). Some industrial dischargers produce offensive odors that are not caused by hydrogen sulfide. Since the control of hydrogen sulfide is presented in Section 5.6, this section will emphasize overall odor control.

Most odors can be controlled in a properly designed, cleaned and maintained collection system. Odor problems usually are due to low velocity flows, long transmission times in the collection system, high temperatures and poorly maintained collection systems. If these problems can be corrected, odor problems would be eliminated. Odor control is usually obtained by controlling the production of hydrogen sulfide (Section 5.6). Masking agents are used to mask or overpower an undesirable odor. They do not control the production of undesirable odors. In some cases a combination of both odor control and masking agents are used to combat odor problems.

One of the most common causes of odors results when the air flow in the sewer above the flowing wastewater is stopped at a siphon or by a small sewer joining a large sewer so low that an air seal is produced. These problems can generally be cured with air lines or air jumpers. These lines are pipes that take air off the top of the inlet structure and return it at the end of the siphon.[8] Wet wells are seldom the site of substantial sulfide generation, even though they are often the place where odors are released from wastewater. An air line or air bypass around the lift station can be used to control odors released from a wet well if the force main is not too long.[9]

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[8] See "Design and Construction of Sanitary and Storm Sewers," MOP 9, pages 157 to 159. Water Pollution Control Federation, 2626 Pennsylvania Avenue, N.W., Washington, D.C. 20037, 1969. Price $5.00 to members; $10.00 to others. Indicate member association when ordering.

[9] See "Process Design Manual for Sulfide Control in Sanitary Sewerage Systems," pages 6-8 to 6-10, U.S. Environmental Protection Agency, Technology Transfer, Washington, D.C., 20460, October, 1974.

5.551 Masking Agents

There are numerous masking agents available on the market which generally consist of a water base and an oil carrier of perfume scents to overpower or mask the objectionable odor. Instead of the sewer smelling like rotten eggs, you can now have your choice of mint, pine, banana, channel #32, or an assortment of other aromas to mask sewer odors.

Obviously a masking agent does not correct the cause of the odor problem. If the original problem is caused by hydrogen sulfide, you still have the other problems created by high concentrations of hydrogen sulfide that include a poisonous or toxic gas that is flammable and explosive. Also hydrogen sulfide can be converted to sulfuric acid which is very corrosive. Therefore, you haven't accomplished anything except to hide a potentially hazardous situation. Probably every agency in the country has used masking agents for the control of odors to satisfy a complaining citizen, but they have not corrected the source of the problem.

5.552 Information Needed from Manufacturer

Use of a masking agent requires the following information:

1. Recommended deodorant or masking agent.
2. Method of application - drip feed, spray, atomizers or blowers.
3. Feed rates and amount of masking agent required to meet feed rates. Time of application, such as late afternoon and early evening, or periods of maximum odor production.

4. Cost of masking agent.
5. Effect upon wastewater treatment plants with biological treatment processes.
6. Effect upon waters receiving effluent from treatment plant.
7. Safety precautions for workers. Any restrictions on use, especially in residential areas.

5.553 Application of Masking Agents

Manufacturer's procedures must be followed exactly to achieve desired effectiveness. Excessive use of any chemical is discouraged because this practice is the same as throwing money down the sewer. Application may be simply removing the masking agent from a one to 55-gallon container using a hose and needle valve. Allow the masking agent to drip into a manhole or lift station wet well at a rate of so many drops per minute. More elaborate equipment and procedures include the use of timers, blowers, atomizers and specially designed nozzles.

5.554 Evaluation

Very careful consideration must be given to these applications because the masking agent is quite expensive. Use may be justified for short time periods until the cause of the problem can be corrected. Remember, masking agents do not eliminate or correct the source of the problem.

5.555 Measurement of Odors

To evaluate the effectiveness of an odor control program, gas detection equipment is available. The U. S. Bureau of Mines approves equipment capable of measuring the concentrations of both ammonia and hydrogen sulfide in parts per million.

5.56 Corrosion

Control of corrosion is discussed extensively in Section 5.6, Hydrogen Sulfide Control. Use of chemicals to control hydrogen sulfide generation is contained in Section 5.66, Hydrogen Sulfide Control Using Chemicals.

5.57 Rodents and Insects

Some collection systems are infested with rodents and insects. Rats are a serious problem in some areas because of the threat to public health and the destruction of food. Effective control of this problem requires assistance from the local health department or animal control agency for the development and implementation of a cooperative eradication program. These agencies can establish a vector (a bug, insect, fly or rodent that can transmit infection) control program and can recommend types of poisons and when and where they should be distributed. Tight sewers with proper traps and connections and good manholes can limit rodent problems.

Insect control can be achieved by an effective maintenance program of flushing slow or stagnant lines periodically during the warm summer months or whenever insects from sewers are a problem. A serious insect problem can be caused by small flies that breed and live in trickling filters and sewers. Cooperation with the local health department can expedite an effective control program.

Control of insects in manholes is best achieved by an effective maintenance program that keeps manholes clean. Use of water to wash and flush manholes can keep them clean. Spraying manholes with an insecticide for dangerous insects and washing down the manhole are good practices if insects are a problem.

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QUESTIONS

5.5L What are the causes or sources of grease problems?

5.5M How can odors be controlled from a wastewater collection system?

5.5N What are two serious shortcomings of the use of masking agents to overcome odors?

5.5O Why should insects and rodents in a wastewater collection system be controlled?

5.6 HYDROGEN SULFIDE CONTROL

by William F. Garber

5.61 Why Control Hydrogen Sulfide?

Hydrogen sulfide (H_2S) is one of the most serious problems confronting wastewater collection system workers. The hotter the weather, the flatter the sewers and the longer the flow time to the wastewater treatment plant, the worse the problem becomes. Some of the problems created by hydrogen sulfide include:

1. Paralysis of the respiratory center and death of workers.
2. Rotten egg odors.
3. Corrosion and possible collapse of sewers, structures and equipment.
4. Loss of capacity of sewer.
5. A flammable and explosive gas.

5.62 How is Hydrogen Sulfide Produced?

The major portion of the sulfide content in wastewater arises from the conversion of sulfate ($SO_4^=$) to sulfide ($S^=$) by bacteria in the slimes in sewers. Materials containing proteins in the wastes are an equally important food for bacteria that produce hydrogen sulfide. Any sulfur containing compound that is available as a food for slimes that reduces oxygen in the wastewater can produce odorous, reduced sulfur compounds, including hydrogen sulfide.

The relationship between hydrogen sulfide (H_2S) and the sulfide ion ($S^=$) in wastewater is tremendously sensitive to pH. The lower the pH, the more hydrogen sulfide is present as compared to sulfide. Therefore in terms of odor and corrosion control, low pH values in wastewater are most undesirable.

Hydrogen sulfide is not only odorous, but upon escape to the sewer walls can be converted to sulphuric acid by other bacteria. In some cases, solutions of sulphuric acid in excess of 40% have been found on walls of the sewer. Where such heavy acid concentrations develop, washing of such areas once a day by such action as rising wastewater flows does not appear to be sufficient to prevent corrosion.

Another important aspect of the establishment of low pH values in a wastewater actively generating sulfide such as has occurred under slug discharges of acids, is the fact that a low pH can result in the swift establishment of a toxic atmosphere. Deaths have occurred as a result of such conditions. Remember that H_2S is about equivalent in toxicity to hydrogen cyanide. Levels of hydrogen sulfide toxicity are as follows:[10]

1. 10 ppm for 8 hours, not dangerous but will produce headache and irritation of eyes and nose.

10 PPM
R 8 HOURS

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[10] California Division of Industrial Safety Orders, Title 8, Section 4.32. Gas concentrations are given in parts per million parts (ppm) by volume.

2. 50 ppm for 8 hours, severe symptoms of poisoning.
3. 300 ppm, minimum concentration known to have caused death.
4. 3000 ppm, quickly fatal.

The ppm concentration of hydrogen sulfide in the sewer atmosphere is quite different from that in the wastewater. A concentration of 1 mg/l (ppm) in turbulent wastewater can quickly produce a concentration of 300 ppm in an unventilated atmospheric space. The tabulation above shows that this concentration may cause death.

In a sewer or waste channel flowing partially full, there will almost always be some oxygen present in the air space above the flowing wastewater. However, sulfide forms and is present in the flowing wastewater. Anaerobic[11] reactions produce sulfide in the slimes while sulfide oxidation is occurring in the surface of the flow. The net sulfide present represents the difference between the amount produced and the amount oxidized.

a. In general, the faster and more turbulent the flow, the more oxygen is dissolved, and thus the more sulfide is oxidized to sulfate ($SO_4^=$). However, manhole turbulence and ventilation often cause corrosion damage in areas immediately downstream from a manhole.
b. Conversely the more sewer slimes arising from more wetted walls, from heavy sand and debris in the bottom and from slower flows, the higher the residual sulfide concentration.

5.63 Control of Hydrogen Sulfide

Design, using our knowledge about sulfide generation, can, in many cases, accomplish the control of sulfide release and thus control much of the odor and corrosion. Designers must realize that the higher the wastewater temperature, the greater the production of hydrogen sulfide. Thus designs acceptable in cooler climates may be unacceptable in warmer climates.

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[11] Anaerobic (AN-air-O-bick). Decomposition and decay of organic material in an environment containing no "free" or dissolved oxygen. If dissolved oxygen is present, aerobic conditions exist.

Another factor of importance in terms of maintenance is the presence of slimes in sewers. Sulfate is split by bacteria living in the sewer slimes, and the more area or habitat for such slimes, the more sulfide produced and the greater the odor, corrosion, and maintenance problems. The cleaner the sewers the fewer the slime bacteria and the smaller the problems caused by sulfide.

Generally speaking, there are only two positive methods of hydrogen sulfide control. These are:

1. Design according to the relationship outlined by Dr. Pomeroy (footnote [12]) so that sulfide release will be minimized, and
2. Use of construction materials that the sulfuric acid will not attack. Odor is still a problem and positive methods of odor control are required.

PROCESS DESIGN MANUAL FOR SULFIDE CONTROL IN SANITARY SEWER SYSTEMS

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[12] U.S. Environmental Protection Agency, "Process Design Manual for Sulfide Control in Sanitary Sewer Systems," EPA Technology Transfer, Washington, D.C. 20460 (October 1974).

If design can be close to the conditions required by the Pomeroy relationships, careful and routine sewer cleaning must be carried out. Excess sand and grit in the sewers not only use up sewer capacity, but slow velocities and provide more slime concentrations for the generation of sulfide. Wastes with strengths (BOD)[13] or temperatures greater than design also can cause corrosion and odors in spite of the use of this design method as will factors such as turbulence at joints and wash-off of corrosion products. In cases where industrial wastes with high BOD and temperatures are encountered, a sewer-use ordinance should be enforced to control these discharges. However, its use should be considered in every installation since it would help minimize both corrosion and odor control.

Provision of materials of construction which will be unaffected by the sulfuric acid resulting from sulfide release is an obvious answer to the corrosion problem. Clay pipe, plastic pipe, the lining of reinforced concrete pipe and structures with materials such as PVC, furane, coal tar epoxy and stainless steel, epoxy lined asbestos-cement pipe, and corrugated steel pipe with asphalt and asbestos linings are materials which have been proposed and/or are offered for this purpose. Clay pipe and reinforced concrete pipe lined with PVC sheets keyed to the concrete are the only materials with a use record long enough at this time to give reliable data for design use. The PVC lining is subject to damage from hard materials floating in the sewer. Where corrosion will occur over some predictable period, sacrificial lining of pipes with high calcium carbonate mortars is used. The entire pipe also can be made using limestone sand and aggregate and high calcium carbonate mortars. Comparative tests have shown that pipe made entirely with limestone aggregate will last 3 to 5 times longer than pipe made with ordinary concrete.

Provision of corrosion resistance still leaves the problem of odor control. Where design cannot provide for the natural oxidation of sulfide and corrosion resistant materials of construction are necessary, carefully designed odor control facilities must be installed. Odor control at treatment plant wet wells may be achieved by withdrawing odorous air and passing it up through trickling filters or bubbling it up through aeration tanks in activated sludge plants. This odorous air is moist and often causes corrosion problems in the transmission ducts.

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[13] BOD (BEE-OH-DEE). Biochemical Oxygen Demand. The BOD indicates the rate of oxygen used by wastewater under controlled conditions of temperature and time.

In addition, methods such as activated carbon towers and packed absorption towers have been successfully used for such odorous air. Masking has been used as an interim solution for acute odor problems. Treatment of the exhausted odors is complicated by the fact that the gas is made up of stench materials and solvents. Removal of both major components is necessary.

Compressed air has been successfully injected into force mains to control problems caused by hydrogen sulfide. This approach is simple and effective in many, but not all situations. Turbulent conditions are critical to dissolve oxygen in the air into the wastewater to successfully prevent sulfide buildup and to oxidize sulfide already present in the wastewater.[14] Aeration of wastewater in lift station wet wells is helpful to keep septic[15] conditions and production of hydrogen sulfide to a minimum. The procedure is especially effective during low flow periods. Be very careful with aeration in a wet well that you do not cause pump cavitation and pumps to become air bound.

Chemical treatment (Section 5.65) of the wastewater is used to control hydrogen sulfide. Chemicals are expensive, but can be effective over a short time period. Zinc and iron salts precipitate the sulfide. Lime dosage at about 8,000 mg/l over an hour will kill the slimes over periods of one day to about two weeks, depending upon conditions. Use of lime can produce large quantities of lime sludge which can cause disposal problems. Other materials providing a pH greater than about 11 or 12 over a half an hour can be used instead of lime. Chlorination is effective, but expensive. Neutralization of the sulphuric acid on the sewer walls by lime dusting or ammonia release has been used. The process is expensive and results have been variable.

As a general summary, however, chemical treatment cannot be considered to be a permanent answer for most locations. It provides relief under acute conditions, but is generally too expensive for continuous use.

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[14] For details on the design of systems to inject compressed air into force mains, see "Process Design Manual for Sulfide Control in Sanitary Sewerage Systems," pages 5-1 to 5-9, U.S. Environmental Protection Agency, Technology Transfer, Washington, D.C. 20460, October 1974.

[15] Septic (SEP-tic). A condition produced by the growth of anaerobic organisms. If severe, the wastewater turns black, giving off foul odors and creating a high oxygen demand.

The collection system worker must urge that engineers consider the available theory in original design and then, themselves, strive to keep the facilities as close to the design conditions as is possible by use of as logical and as frequent a cleaning schedule as is feasible and the control of waste materials discharged to the collection system. Where this is not possible, resistant materials of construction, odor treatment and chemical dosage in acute situations may be necessary. The maintenance worker's options are limited, but knowledge of the possible causes of trouble and of the available solutions enable the worker to make the most logical use of available forces and procedures.

Lawrence[16] forcefully pointed out that sewer maintenance problems vary with location and thus in terms of wastewater temperature, strength, and age as well as design factors. His paper summarizes in considerable detail the factors of importance and which portions of the country are particularly susceptible to maintenance problems.

5.64 Collection System Maintenance and the Treatment Plant

Sewer maintenance and sewer design have a definite and important effect upon wastewater treatment. This is particularly true of the south and southwest and where separate sewers with long flow times are constructed. However, with the mandated implementation of secondary treatment throughout the nation, this factor should be examined by everyone. Table 5-3 is an example of degradation in the wastewater which did occur in a wastewater collection system and did have a substantial effect upon treatment plant operations. It also shows that such degradation[17] can be measured by either the oxidation reduction potential (ORP) or the dissolved sulfide content.

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[16] Lawrence, C.H., "Sewer Corrosion Potential," Journal Water Pollution Control Federation, Volume 37, 1067-1091, August 1965.

TABLE 5-3

DISTANCE TO TREATMENT PLANT vs. DISSOLVED SULFIDE, mg/l
EFFECTIVE BOD 304 MG/LITER

Distance Upstream of Treatment Plant, Miles	ORP, E_H* in MV	Dissolved Sulfide, mg/liter
9	+ 258	0.2
6	+ 122	0.6
5	+ 70	1.1
3	+ 50	1.2
0	+ 48	1.8

*E_H is the potential required to transfer electrons from the oxidant to the reductant in millivolts, MV.

Obviously by keeping deposits and slimes to a minimum and flow velocities high enough, sewer maintenance can affect the degradation of wastewater. Sewer design is, of course, very important (Chapter 3), but collection system workers must try to make what is available produce the best possible results.

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[17] Degradation (de-grah-DAY-shun). The conversion of a substance to simpler compounds. For example, the degradation of organic matter to carbon dioxide and water.

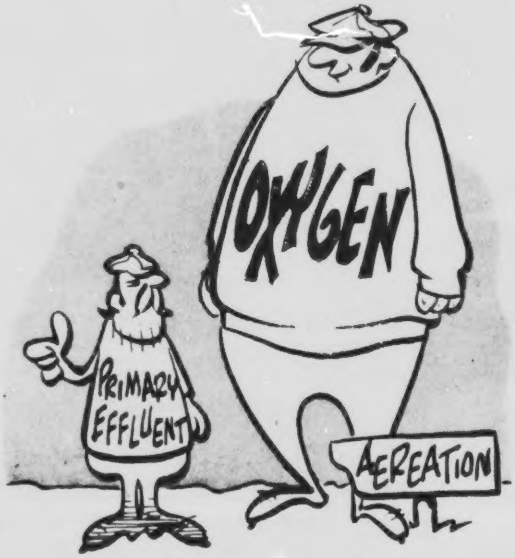
Degradation of the wastewaters in the collection system produces several undesirable impacts at a wastewater treatment plant:

1. Odor and corrosion problems in plant facilities.

2. Initial or immediate oxygen demand on biological treatment processes.

The effect of low ORP and high dissolved sulfide content upon odor and corrosion is evident.

The initial oxygen demand at the start of a biological treatment process may arise in most part from the septic condition of wastewater arriving at the treatment plant. At Los Angeles the initial oxygen demand is in the order of 50 mg/l-hour. This means that a substantial amount of oxygen must be available at the moment the primary effluent reaches the aeration basins in order to reestablish aerobic[18] conditions and to reduce problems from the release of odors.



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[18] Aerobic (AIR-O-bick). A condition in which "free" or dissolved oxygen is present in the aquatic (water) environment. If no dissolved oxygen is present, anaerobic conditions exist.

QUESTIONS

5.6A What problems are created by the presence of hydrogen sulfide?

5.6B What are the sources of hydrogen sulfide in sewers?

5.6C List the factors that you consider important in the production of hydrogen sulfide.

5.6D How does collection system maintenance affect the wastewater treatment plant?

5.65 Chemical Control of Hydrogen Sulfide

In the preceding pages you have learned that hydrogen sulfide (H_2S) is toxic, can cause corrosion, and in high concentrations is flammable and explosive. Hydrogen sulfide is produced by sulfur reducing anaerobic organisms that can thrive in a wastewater collection system. These sulfur reducing organisms require the following environment to thrive:

1. The absence of dissolved oxygen (DO) in the wastewater.
2. The presence of sulfate or sulfur compounds. These compounds are present in most wastewaters or are produced by the degradation of materials containing proteins.
3. The greater the strength (higher BOD) of the wastewater, the greater the rate of sulfide generation.
4. The warmer the temperature of the wastewater, the more favorable the environment.
5. The slower the flow velocity and the dirtier (more debris) in the sewer, the better the conditions for hydrogen sulfide generation.

Chemical control of hydrogen sulfide generation may consist of use of one of the six chemicals listed below in order of popularity of application:

1. Chlorine (Cl_2)
2. Hydrogen peroxide (H_2O_2)
3. Pure oxygen (O_2)
4. Air
5. Lime ($Ca(OH)_2$)
6. Sodium hydroxide (NaOH)

5.651 Chlorine (Cl_2)

The most widely used chemical for hydrogen sulfide control has been chlorine injected into the wastewater flow at various points along the collection system. Sewer lift stations often serve as injection sites due to the availability of the site and the required utilities such as water and power to operate the chlorination equipment.

Chlorine doses of 10 to 20 mg/l have been effective in controlling the production of hydrogen sulfide in many collection systems. Doses of chlorine at these levels are toxic to most organisms in the wastewater. When these aerobic organisms are inactivated or killed, they no longer require oxygen or exert a BOD. This permits the wastewater to remain aerobic longer and delays the start of anaerobic decomposition which produces sulfide. Chlorine also is toxic to the organisms that convert sulfate to sulfide.

Chlorination may be accomplished by the use of chlorine gas and chlorinators or by the addition of a hypochlorite solution. Hypochlorite is available as a dry powder, in tablet form, or as a liquid usually as sodium hypochlorite.

When considering the chlorination of a wastewater collection system, beware of the following problems:

1. Chlorine is a highly toxic, oxidizing chemical. Leaving this chemical unattended in or adjacent to residential areas with the constant possibility of leaks may result in serious injury to the public and to private property.

2. Chlorine requires application equipment including evaporators (if use rates are high), chlorinators, injectors, solution diffusers in the sewer line, and possibly an air gap water system with separate injector water pumps. All of this equipment must be properly maintained.

3. For effective results, the chlorine solution must be added at a point of high turbulence where it mixes instantly with the wastewater flow.

4. Under extremely low flow conditions or if the solution diffuser is improperly designed, chlorine could be released from the diffuser and cause serious damage to the chlorination equipment.

5. If chlorine dosage is to be properly controlled to meet collection system sulfide generation rates or daily variation of flows, then flow metering and chlorine feed control equipment will be required.

6. Chlorine costs are increasing rapidly. Large amounts of energy are required to produce chlorine. If a chlorine shortage occurs, chlorine may not be available for hydrogen sulfide control in collection systems.

7. NEVER apply an overdose of chlorine near a wastewater treatment plant. Chlorine is toxic to organisms and can kill aerobic organisms in secondary biological treatment processes.

CHLORINE SAFETY

Any person using chlorine should be thoroughly trained by the chlorine supplier in safe procedures for storing and handling chlorine. Workers must receive instruction in the use of self-contained breathing apparatus and the use of chlorine container repair kits.

For additional information on chlorine safety, read:

1. "Chlorine Manual," (4th edition), The Chlorine Institute, Inc., 342 Madison Avenue, New York, New York 10017. Price $1.00.

2. "Chlorine -- Safe Handling," PPG Industries, Inc., Chemical Advertising, 9 North, One Gateway Center, Pittsburgh, Pennsylvania 15222.

5.652 Hydrogen Peroxide (H_2O_2)

Hydrogen peroxide was first used in the wastewater field for providing additional oxygen (O_2) to the activated sludge process in wastewater treatment plants. Hydrogen peroxide has been found beneficial in collection systems for hydrogen sulfide and odor control. Wastewater can be kept aerobic by the application of large amounts of hydrogen peroxide.

The hydrogen peroxide you buy in the drugstore for medical purposes has a strength of 3 percent, while the hydrogen peroxide used in a collection system may have a strength from 35 to 50 percent.

Application of Hydrogen Peroxide

Your hydrogen peroxide supplier should be very helpful in establishing your application program. Control of hydrogen sulfide using hydrogen peroxide relies on two major factors:

1. Conditioning Program. To inactivate and control slimes, dose with sodium hydroxide ($Na(OH)$) or calcium hydroxide ($Ca(OH)_2$). Lime ($Ca(OH)_2$) dosage at about 8,000 mg/l over an hour will kill the slimes over periods of one day to about two weeks, depending on conditions. However, disposal of lime sludge must be considered. Slimes are not affected by reasonable doses of hydrogen peroxide. Slimes should be controlled before the beginning of the application of hydrogen peroxide. Periodically the slimes may have to be controlled during the regular hydrogen peroxide application program.

2. Application Program. Effective control of hydrogen sulfide by hydrogen peroxide requires the feeding of sufficient hydrogen peroxide during the daily variation of flows to be sure sufficient amounts of hydrogen peroxide are fed to the wastewater to neutralize the hydrogen sulfide and maintain aerobic conditions. Unlike chlorine, excessive hydrogen peroxide is not detrimental to the wastewater treatment plant. However, excessive dosage of any chemical is throwing money down the sewer.

Recommended doses:

Hydrogen Peroxide Concentration, %	Dose Rate, mg/l H_2O_2 per mg/l of total H_2S
35	13 to 15 mg/l
50	11 to 13 mg/l

Occasionally repeat the preconditioning dosage of sodium hydroxide or calcium hydroxide (lime) to control slime growth.

The actual method of applying hydrogen peroxide will be recommended by the supplier. Usually either a drip feed or pumping system is used and neither system is as expensive to install or as complex as a chlorination system.

Hydrogen peroxide, like chlorine has the following disadvantages:

1. Must be isolated and protected from access by the public, especially children.
2. Is very corrosive and must not be contaminated by foreign material.
3. Containers must be protected from the sun to prevent heat build up.

HYDROGEN PEROXIDE

HYDROGEN PEROXIDE SAFETY

1. Follow manufacturer's directions carefully.
2. Wear goggles and rubber gloves. Hydrogen peroxide must not come in contact with skin or eyes.

3. Avoid getting hydrogen peroxide on your clothing or shoes and especially combustible materials because drying may cause a fire.

4. In case of a spill or a fire, use water only to dilute the hydrogen peroxide or put out the fire.

5. Keep flames, open lights, and sparks away from hydrogen peroxide containers and the application system.

5.653 Pure Oxygen (O_2)

With the great thrust to clean up the environment and the desire to control water pollution, many new treatment plants are using pure oxygen activated sludge systems. Pure oxygen systems are widely used by various industries and became known to the public through the space program.

If a wastewater treatment plant is producing oxygen for the activated sludge process, additional oxygen can be produced for introduction into the main intercepting sewers to control the production of hydrogen sulfide. Injection of gaseous oxygen into wastewater by using compressors and diffusers helps maintain aerobic conditions in the sewer.

Disadvantages of using pure oxygen include:

1. Must be kept free of petroleum products.

2. Uses specially designed compressors, dissolution diffusers, and shut down and purge control systems to prevent ignition hazard that could touch off the explosive condition of the oxygen.

3. Must be isolated from public access.

Pure oxygen systems will not be a common alternative to control sulfide in gravity collection systems. These systems have been used effectively to inject oxygen into wastewater in force mains. When evaluated for use in collection systems, an extensive engineering study and design will be required.

5.654 Air

Air is obviously the cheapest chemical available because it is free. There are no hazards to workers involved in handling air. Another advantage of applying air at lift station wet wells is that the resulting turbulence keeps deposits of solids from accumulating during low flows.

A limitation of applying air is the noise from air compressors. The most serious problem using air is the difficulty of transferring sufficient oxygen from the air to the wastewater to produce and maintain aerobic conditions.

6.655 Lime ($Ca(OH)_2$)

Lime can be used to control hydrogen sulfide. Addition of lime can increase the pH of the wastewater to a level where hydrogen sulfide will not exist. A disadvantage of this approach is the problem of disposing of lime sludges.

5.656 Sodium Hydroxide (NaOH)

by Blake Anderson

Sodium hydroxide (caustic soda) has been used extensively by the Los Angeles County Sanitation Districts (LACSD) for many years to control sulfide production in the wastewater collection system for flows under 5 cfs. Periodic treatments of a sewer in which sulfide is produced will usually maintain control. Treatment consists of feeding enough sodium hydroxide into a sewer to raise the pH of the wastewater to 12.5 or greater for a half-hour period. The high pH inactivates the slime layer in the sewer and sulfide production stops. In the average sewer with a sulfide problem, this treatment is necessary every two weeks during the summer. In a few cases more frequent treatment is necessary.

When testing indicates that a sewer is beginning to produce sulfide past an unacceptable level, then treatment is scheduled. "Unacceptable level" is very subjective and difficult to define. In some sewers after treatment the sulfide concentration falls way off and then suddenly jumps back to pretreatment levels after a couple of weeks. This level is clearly unacceptable and treatment should be scheduled. In other sewers the recovery of sulfide production to pretreatment levels may begin slowly at first after a week or so. These slightly increasing levels can indicate that higher production will shortly return and treatment should be scheduled before problems develop. Only experience will tell you what to expect from a particular sewer.

The sodium hydroxide is hauled to the treatment site in a 2500 gallon vacuum truck[19] purchased by the LACSD for this particular purpose. Parked over an open manhole, the truck feeds the sodium hydroxide through a rotometer and into the manhole for 30 minutes. 100 to 125 gallons of 25 percent sodium hydroxide are required for each cubic foot per second of wastewater flow. The high pH wastewater travels down the sewer and will inactivate the slime layer as long as the pH remains high. Dilution from subsequent sidestreams and neutralization by acidic substances will eventually bring the pH to near neutral levels.

Sodium hydroxide is purchased by the LACSD in large bulk quantities at 50 percent concentration. The sodium hydroxide is diluted to 25 percent concentration in a 15,000 gallon storage tank and held there for future use. Store the sodium hydroxide in the dilute form to reduce its viscosity and to keep it from crystallizing. Cost of the 25 percent solution is approximately 23 cents per gallon based on a December, 1975 bid price.

Sodium hydroxide also is obtained free by the LACSD as "spent caustic" from industries. This sodium hydroxide is usually at a 3 to 6 percent concentration and is usually combined with other materials. The spent caustic is tested occasionally to determine if it contains the materials of the particular industry in high enough concentrations to be harmful to workers, the environment, or to the wastewater collection system. The major disadvantage of using spent caustic is the large quantity required--usually 2000 gallons per treatment.

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[19] At one time a 500-gallon tank placed in an old dump truck was used to transport the sodium hydroxide. This equipment is fairly inexpensive and is ideally suited for the needs of a small collection system.

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Hauling back and forth between the industry and various treatment sites takes a great deal of driver and truck time and usually only one treatment per load is possible. Purchased sodium hydroxide is much more concentrated and several treatments per truck load can be made.

A major consideration when using sodium hydroxide is the side effect that high pH can have on wastewater treatment plants using biological processes. If the sodium hydroxide enters a downstream treatment plant at a high enough pH, an upset of a biological process can occur. If a pH of near 9 or more is anticipated, then bench scale testing should be made to determine the effects of a high pH slug entering the treatment plant. Consult your staff engineer or a consulting engineer for advise in this area.

The LACSD has used several methods to control the effects of high pH on its activated sludge secondary treatment plants. First, there is simple dilution. At some treatment plants the flow is so great that the high pH wastewater coming from the treated sewer line is diluted to near neutral pH levels. Second, there is diversion around the plant. At some treatment plants that have been built to relieve sewer capacity downstream, it is possible to pull stop logs and divert the high pH wastewater around the plant and on to a downstream plant for a short period. Third, there is interception. At one treatment plant the early morning flows are very low. The sodium hydroxide is fed at the treatment site. The 2500 gallon treatment vacuum truck along with an additional 4000 gallon vacuum truck intercept the high pH wastewater three hours later just before it enters the treatment plant. This is accomplished by dropping a stop log in the line to dam the sewer and then pumping the high pH wastewater out of the sewer and into the trucks when it arrives.

Safety is another important consideration when using sodium hydroxide. This is a caustic material that will cause burns. Handling it should be done wearing a face shield and gloves. When treating a sewer line it is important to coordinate with all your maintenance crews and with construction contractors to avoid harming them.

The chief advantage of sodium hydroxide is its lower price compared to other chemicals which require continous application. Even with the cost of workers and equipment included, the LACSD have found it much cheaper than the other principal chemical methods. The chief disadvantage is the amount of attention that has to be given to hauling and applying sodium hydroxide. Some of the other chemical methods probably require less attention and time. The economic benefits of using sodium hydroxide vs other chemicals should be determined for each particular collection system. Labor, materials, and equipment should all be included in such an analysis.

5.657 Other Chemicals

Potassium permanganate has been tried and found not to be cost effective in most areas. Ozone generators have been used on a small scale and also found not to be cost effective. Power requirements to produce ozone from the atmosphere or even with pure oxygen available to supply the generator have been very costly to date.

5.66 Summary

Many factors are important for effective control of hydrogen sulfide. You must become aware of the fact that your job involves more than the obvious cleaning of sewers by removing sand and obstructions. You have an active biological system in the sewers. Control of this system will not only affect you directly in regulating corrosion and odor problems, but also will have a direct bearing upon the downstream wastewater treatment plant. You may aid treatment plant digestion by accomplishing some of the breakdown in the sewers; but you also may substantially increase the immediate oxygen demand upon biological treatment processes. Collection system workers need to reach beyond the complexities and difficulties of their mechanical problems and recognize the need to consider the biological ecosystem in the wastewater collection system too.

OZONE
POTASSIUM PERMAN
$

The best method of hydrogen sulfide control is proper collection system design and maintenance. If chemical control is required, chlorine and hydrogen peroxide appear the most feasible. Aeration may be helpful when properly applied at selected locations. Selection of a chemical should be based on an analysis of the magnitude of the problem and a comparison of the costs and effectiveness of the alternatives.

QUESTIONS

5.6E What are three potential methods of chemical control of sulfide?

5.6F Why is chlorine effective in controlling sulfide?

5.6G How does hydrogen peroxide control sulfide generation?

5.6H Pure oxygen may be feasible to control sulfide under what conditions?

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

(Lesson 5 of 5 Lessons)

Write the answers to these questions in your notebook before continuing to the objective test on page 5-213. The question numbering continues from Lesson 4.

24. Why is the method of chemical application important and why must it be done correctly?

25. How would you decide whether or not to select an untested chemical? Describe a testing and evaluation procedure.

26. Why must insects and rodents be controlled in a wastewater collection system?

27. What factors contribute to the production of hydrogen sulfide in a collection system?

28. How would you attempt to control odors from a wastewater collection system?

29. What safety precautions must be exercised when using chlorine to control sulfide?

30. Explain the disadvantages of using chemical methods to control sulfide.

31. Why is the proper operation and maintenance of a wastewater collection system important to the operator of a wastewater treatment plant?

SUGGESTED ANSWERS

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

5.1A To operate and maintain a wastewater collection system properly, try to achieve the following objectives:

1. Minimize the number of stoppages per mile of sewer.
2. Minimize the number of odor complaints.
3. Minimize the number of lift station failures.

5.1B When a stoppage or blockage occurs in a sewer, wastewater will back up and overflow onto the street or into homes and businesses.

5.1C Major causes of stoppages include obstructions such as roots, grease, debris, broken pipe or joint failures. Vandals, construction work, the forces of nature, and intersecting flows also can cause stoppages.

5.1D To identify the cause of a stoppage, try to identify the source of the problem by determining if:

1. The line has a history of previous stoppages (a root or grease line).
2. Trees are growing near the line.
3. New building sewers or new lateral or branch sewers have been installed recently.
4. Repairs have been made recently to the sewer or to the street, such as street resurfacing.

5.1E When a grease or root stoppage causes flooding, hand or power rodding is the first method suggested to attempt to clear the stoppage.

5.1F High velocity cleaners are an effective tool for removing grease build ups in sewers up to 24 inches in diameter. A parachute or bag may be a better method for larger diameter sewers.

5.1G A stoppage caused by roots can be cleared by either a power rodder or a hand rodder. A high velocity cleaner also is effective.

5.1H Advantages:

1. Very effective in cleaning flat, slow flowing sewers.
2. Efficient in removing grease, sand, gravel, and debris in smaller diameter sewers.
3. Effective in breaking up solids in manholes and washing structures.
4. May be used to eliminate emergency stoppages in sewers.

Limitations:

1. Efficiency and effectiveness in removing debris from larger diameter sewers decreases as the cross-sectional area of the pipe is increased.
2. When used by an inexperienced operator, may cause a back up into residences.

5.2A Three sewer line hydraulic cleaning methods include:

1. Balling
2. High Velocity Cleaner
3. Flushing
4. Sewer scooter
5. Kites
6. Tires
7. Poly pigs

5.2B When hydraulic cleaning methods are being used, care must be taken to be sure basements and homes are not flooded.

5.21A Balling can remove deposits of inorganics (grit) and grease from sewers.

5.21B Balling is commonly used in preventive maintenance programs because it is very effective in reducing stoppages and economical in comparison with other methods.

5.21C The frequency of balling a sewer in a preventive maintenance program may vary from six months in some sluggish lines to three years in other lines. To determine the frequency of balling, study your district records and base the frequency of cleaning on:

1. Number of stoppages and complaints.
2. Size of area the collection system serves.
3. Type of wastes carried by collection system.

5.21D Three workers are needed for a balling crew:

1. Maintenance Equipment Operator
2. Maintenance Man I
3. Maintenance Man I

5.21E Additional water can be obtained from fire hydrants or a water truck to provide the necessary head for a balling operation when flows in the sewer are low.

5.21F The manhole jack or roller is essential to guide the tag line into the sewer without causing unnecessary wear and to give proper rolling action as the tag line is pulled back and forth or in restraining the ball.

5.21G The purpose of an "air gap" device is to prevent the backflow of wastewater into a drinking water supply.

5.21H A sewer ball must be properly inflated to cause good cleaning action, but not so tight the water cannot flow around the ball and carry it downstream. If the ball is too loose, it only will float downstream with little cleaning action.

5.21I Material cleaned from the sewer is caught in the downstream manhole by using a shovel with the spade shaped like the bottom of the sewer. The material is shoveled into a bucket and then removed from the manhole.

5.21J The ball should move downstream slowly at a steady rate.

5.21K A ball could stop moving downstream because:

1. Of a large deposit.
2. Of a build up of material in the line below the ball.
3. The ball has hit a bad tap.
4. Of crushed or offset pipe.

5.21L To determine what caused the ball to stop moving downstream:

1. Try to "bounce" the ball back and forth in the line to remove large or stubborn deposits.
2. Consult TV log of line. If line has not been televised or not recently, request that the line be televised.

5.21M To remove a stoppage below a ball, use a power rodding machine, hand rod, or a high velocity cleaner at the downstream manhole.

5.21N The following safety precautions should be taken during a balling operation:

1. Avoid flooding basements, homes or businesses.
2. Safely route traffic around job site.
3. Practice manhole safety from start to finish.

5.22A High velocity cleaning machines are used to:

1. Open stoppages.
2. Remove grease.
3. Clean lines of debris.
4. Wash manholes and wet wells.

5.22B Nozzles attached to the end of the hose create high water velocities that clean the sewers.

5.22C One person can operate the high velocity cleaning machine. The crew consists of two or more persons, depending on field conditions.

5.22D Traffic can be warned of high velocity cleaning units set up in a street by use of:

1. Rotating beacon on top of cab of truck.
2. Flag stands with "men working" signs.
3. Safety cones.
4. Flagmen.

5.22E The water tank should be filled close to the working area because it is difficult and dangerous to drive a truck with a tank full of water.

5.22F To clean a given area or subdivision, start at the top or highest point in the collection system.

5.22G Direct the nozzle upstream in the sewer.

5.22H Send the nozzle up the line and bring it back to the downstream manhole enough times to reach the upstream manhole and return without bringing back debris.

5.22I When loosened materials build up and overflow the debris trap, pull hose and nozzle out of manhole. Retest manhole atmosphere. Allow a worker to enter manhole and shovel debris into a bucket for removal from manhole.

5.22J The nozzle must be kept moving at all times or it could be stuck in the line and cause flooding in homes.

5.22K If flow stops in the working manhole, pull the hose and nozzle out at once and start over again to remove the built up material that is causing the stoppage.

5.22L High velocity cleaning machines clear stoppages by using the forward jet to provide cutting action ahead of the nozzle.

5.22M When cleaning from a manhole to a cleanout, be careful not to knock the cleanout covers out of place or get the nozzle stuck.

5.22N When the nozzle becomes stuck, try:

1. Pulling the nozzle back with the water pressure off.
2. Moving nozzle to upstream manhole, removing nozzle, and pulling hose back.

5.22O During cold weather, be sure to keep equipment from freezing. The high-pressure pump must be properly drained, the equipment can be heated with a heater, or water can be circulated through the pump and hose.

5.23A Flushing is commonly used at the beginning of the collection system where low or sluggish flows permit the deposition of solids.

5.23B Lower than expected flows at a downstream manhole during a flushing operation indicates that there is a restriction in the upstream segment of the line and that additional cleaning is required.

5.23C Flushing helps control rodents and insects in sewers by sending a sudden surge of water down the line that can wash them out or drown them.

5.23D A flushing crew can consist of two workers provided neither of them enters a manhole. If a manhole must be entered for any reason, such as to remove debris, a third worker must be available so two workers remain topside to retrieve the worker in the manhole if an accident occurs.

5.23E The flushing operation starts at the extreme upstream end of the collection system.

5.23F Manholes are cleaned with a pressure hose by washing the manhole barrels and shelf usually prior to flushing the line.

5.23G Factors that influence the length of line that can be flushed in one day include:

1. The number of manholes that have to be entered and cleaned.
2. Location of manholes - street or backyard easement.
3. Whether water for flushing is provided by the tank truck or a fire hydrant and its location with respect to the location of the manhole.

5.23H Safety precautions that must be taken during a flushing operation include:

1. Traffic considerations.
2. Atmosphere in manholes (toxic and explosive gases and oxygen level).
3. Avoid flooding of residences and businesses.

5.24A The cleaning action of a sewer scooter results from the high velocity of water flowing around the shield of the scooter.

5.24B Scooters are capable of removing large objects and such other material as brick, sand, gravel, and rocks. They are considered more effective in larger lines (over 18 inches) and have been used to remove grease in these lines.

5.24C When using a scooter, care must be taken where sewers are shallow to avoid flooding of homes or businesses because of the build up of water in the sewer.

5.24D Three workers are needed for the safe and efficient operation of a scooter crew. When cleaning lines with a 15-inch diameter or larger or in heavy traffic, additional crew members may be needed.

5.24E The debris trap installed in the downstream manhole is designed to allow water to pass and to hold back the debris.

5.24F Before setting equipment up in the street, safety measures need to be taken to warn and control traffic and to insure safe working conditions in manholes.

5.24G The purpose of the manhole jack or control cable guide is to allow the control cable to take the strain without rubbing on the sharp edge of the pipe during the cleaning operation.

5.24H During set up, the level of water in the manhole and sewer above the scooter can be controlled by pulling firmly on the head shield and allow the excess water to flow on down the sewer.

5.24I To determine if the folding mechanism is working properly when the scooter starts downstream, give the control line a short, smooth pull back two or three feet and hold. If the build up of water in the manhole starts to go down, you will know the folding mechanism is working properly.

5.24J The recommended depth of water in a manhole during a scooter cleaning operation is three times the diameter of the pipe. The deeper the water the more effective the cleaning action, bur care must be exercised to avoid flooding homes and businesses.

5.24K If the flow in the collection system is not sufficient for effective cleaning, add more water to the upstream manhole by using water from the tank truck or from a fire hydrant.

5.24L If the scooter slows or stops during the cleaning operation, it is probably due to an accumulation of material ahead of it.

5.24M When material builds up ahead of a scooter, give the control line a short, smooth pull back four or five feet. This will allow the upper half of the head shield to fold back and a surge of water to flush the accumulated material on downstream.

5.24N Someone must watch the flow of material into the lower manhole to prevent a buildup of material that could flow over the debris trap.

5.24O Before debris can be removed from a manhole,

1. Shut off any extra water being put into the upper manhole.
2. Hold up the progress of the scooter.
3. Recheck manhole for gases found in sewers before entering.
4. Worker entering manhole must have proper safety equipment.

5.24P Cables should be examined at the start and finish of each section to avoid having a cable break when the scooter is in the middle of a sewer.

5.25A Instead of using a sewer ball, larger diameter sewers are cleaned using kites, bags, or tires.

5.25B Poly pigs are frequently used to clean force mains.

5.31A Sewer line mechanical clearing techniques include:

1. Bucket machines
2. Power rodders
3. Hand rods

5.31B Hydraulic cleaning techniques should be given first consideration for removing solids deposited in sewers because of simplicity and costs.

5.31C Hydraulic cleaning techniques may not be the best solution for removing roots or debris that enters the collection system from breaks or repairs in pipes or manholes or from some types of industrial waste discharges. Nozzle action from a high velocity cleaner can develop a negative pressure that could hasten the collapse of a bad section of pipe.

5.31D Power bucket machines should be used mainly to remove debris from a break or other debris that cannot be removed by hydraulic cleaning techniques. They should not be used as a routine cleaning tool on a regular basis.

5.31E The working machine pulls the bucket out of the manhole.

5.31F The porcupine tool is quite effective for final clean up since the bristles have a scrubbing action.

5.31G A power bucket crew should consist of at least three workers and four workers are recommended.

5.31H An overnight line might be left in a sewer line overnight if the job is not completed before the end of the day. The overnight line is used to speed start up the next day and avoid the time and effort to thread the sewer again.

5.31I A fool-proof communication system must be devised and used because someone can easily be injured if the proper signal is not sent, received, or is misunderstood.

5.31J The purpose of the swivel is to keep the rope and cable from twisting.

5.31K Usually the size of clearing bucket is determined by the size of the sewer being cleared. Experience and history of the sewer may dictate the use of a bucket smaller than the actual sewer size. Also the size of the manhole opening limits the maximum size of the clearing bucket.

5.31L As the bucket is pulled upstream into the material deposited in the sewer, a definite resistance can be noticed when the bucket is full. Always make a few short pulls to check out not only the amount of material, but also the equipment and the set up.

5.31M The debris in the bucket is first dumped on the street and then loaded and hauled away or dumped into a loading chute that moves the debris directly into a dump truck.

5.31N A sand trap is inserted in the downstream manhole to catch debris loosened by the bucket, but not retained in the bucket.

5.31O The line may be cleaned with a porcupine cleaning tool after a bucket has been pulled through the line.

5.31P The porcupine should be pulled downstream because it can seal off or plug the line and cause the wastewater to back up in the line.

5.31Q The bucket should be pulled upstream to minimize stoppages that could develop when large amounts of debris or roots are encountered.

5.31R The location of the bucket in the sewer line must be known at all times so if it ever becomes stuck, it can be dug up.

5.31S The condition of the equipment should be inspected regularly to avoid breakdowns. If a cable should come loose from the bucket, it could be very difficult to retrieve the bucket.

5.31T When working around cable operated equipment, keep your hands clear of the drum. Use a manhole hook to guide the cable. In an instant, your hand or fingers can become entangled and the operator cannot stop the machine fast enough to avoid injury.

5.31U Locations of problem areas must be recorded so future cleaning crews will know what to expect and hopefully avoid serious problems. Also it may become necessary to repair a sewer and this too should be noted for future reference.

5.32A Power rodders can be used for:

A. Routine preventive maintenance.
B. Scheduled clearing of grease deposits, roots, and flat lines.
C. Threading cable for other cleaning equipment.
D. Emergency use for stoppages.

5.32B Sectional power rodders are capable of clearing lines with diameters up to 12 inches and distances up to approximately 750 feet.

5.32C Advantages of sectional rod:

1. When a rod is broken, this section can be replaced.
2. Repair can be done quickly in the field.
3. The broken section can be replaced with a new section at once or the rod can be recoupled, adding new rod only when more footage is needed.

5.32D Advantages of continuous rod:

1. Greater distances can be obtained.
2. Loading the machine with new rod is fast and simple.

5.32E Two workers are needed to properly operate the power rodder and three are recommended.

5.32F When a two-worker crew has to enter a manhole, they must obtain assistance before anyone enters a manhole. Two workers must be topside at all times when someone enters a manhole.

5.32G A round stock corkscrew is a first-step clearing tool for rodding where conditions are unknown.

5.32H Spring blade cutters can be used to remove grease.

5.32I Power rodders are more effective in smaller lines.

5.32J A sewer may be rodded either upstream or downstream from a manhole.

5.32K The purpose of the leader tool installed on the end of the rod is to prevent the sharp end of the rod from damaging the interior of the guide hose.

5.32L A debris trap is necessary to keep loosened roots, grease chunks or other material from going farther downstream and possibly causing a stoppage.

5.32M To determine which clearing tool to use, study:

1. History of line being cleared.
2. Look for grease in manhole.
3. Look for trees growing close to the sewer.

5.32N Use a round stock corkscrew to try to clear a stoppage.

5.32O After a stoppage has been cleared, examine the material at the downstream manhole and try to determine if the stoppage was caused by grease, grit, or roots. When the probable cause of the problem has been identified, then select the best tool to correct the problem.

5.32P When changing to another clearing tool, NEVER take hold of the clearing tool until it has stopped rotating and the power rodder is shut down. Also be careful the rod is not coiled in the sewer and won't unwind from this torque when the tool is moved about.

5.32Q The location of the clearing tool in the sewer must be known at all times so if the tool ever gets stuck, you will know exactly where to dig to recover the tool and open the sewer.

5.32R The speed of the rod in or out, and the rotation speed, depend primarily on existing conditions in the sewer and also upon the experience of the operator.

5.32S Water is sometimes added to the opposite manhole during power rodding if existing flows are insufficient in order to keep the rod cool and to increase the effectiveness of the clearing operation.

5.32T Use a pick-up tool to recover a broken rod.

5.32U Broken rods must be recovered. If they can't be recovered by a pick-up tool or flushed out with a high velocity cleaner, the line must be dug up to recover the tool.

5.32V Rods and clearing tools can be under tension and can be very dangerous if they get away from you.

5.32W Occasionally the rod should be run out on the top of the ground and inspected for bent pieces and loose couplings. When couplings are allowed to stay loose, the rod will wear and become weak at that point.

5.32X The rod should be cleaned when it is returned to the reel to prevent the buildup of grease and grit which will cause wear on the rod.

5.32Y Everyone on a rodding crew must know their own job and everyone else's job so everyone can be familiar with the over-all operation.

5.32Z The engine of the power rodder should have the maintenance and care as recommended by the shop foreman or manufacturer's directions.

5.33A Hand rods are used to clear many stoppages, especially during the night or on weekends.

5.33B A hand rodding crew usually consists of two workers. They never enter manholes. When a manhole must be entered, a third worker must be available in case the worker in the manhole needs help.

5.33C A power rod has a greater penetration into a sewer than a hand rod.

5.33D When a bare rod is exposed on top of the ground or street, care must be taken that the rod does not injure someone or damage equipment and gardens.

5.33E The kind of tool used at the end of the rod depends on the sewer's condition and the type or source of the problem we are trying to correct.

5.33F If hand turning a rod does not clear the stoppage, put the gasoline driven power drive unit on the rod and use this unit. If this procedure doesn't work, try the power rodder.

5.33G When working a rod upstream to clear a stoppage, be careful that the surge of water that is released when the surge is broken does not:

1. Shoot up the rod guide tube and get someone wet.
2. Force the rod back out the guide tube.

5.4A Cleaning equipment must be properly maintained at all times so we can do our jobs quickly and effectively.

5.4B A worker can learn how to maintain cleaning equipment from the manufacturer's directions and from experience.

5.4C The objective of cleaning equipment maintenance is to keep equipment in an existing state of repair and efficiency and preserve equipment from failure.

5.4D The three essential factors for an effective equipment PREVENTIVE maintenance program are TOOLS, TIME, and TALENT (knowledge).

5.4E The crew foreman or equipment operator is responsible for the proper maintenance of cleaning equipment.

5.4F Bucket machine crews should have enough tools for both upstream and downstream machines because often the crew is considerable distance apart, especially when working on easements.

5.4G The number one maintenance problem with the cable scroll and level wind system is lack of proper lubrication.

5.4H Cable clamps should be tightened at the start of each day.

5.4I When a bend is noted in a stabilizer leg, get it straightened now.

5.4J If the tension on the drive head chain is loose, the drive dogs tend to ride up and over rod couplings.

5.4K The torque on the drive rollers of a continuous rodder depend on the rod wear.

5.4L Maintenance of hydraulic units includes:

1. Look for and repair leaky fittings and hoses.
2. Keep oil filter clean.
3. Maintain proper hydraulic oil level.

5.4M The operator of a high velocity cleaner unit must be familiar with all aspects of the machine so the operator can properly operate and maintain the unit.

5.4N When operating a high velocity cleaner, always be alert for:

1. Odd or suspicious sounds.
2. Higher or lower than usual RPM to maintain pressure.
3. Sluggish reel return.

5.4O Daily check oil levels of:

1. Engine
2. Pressure pump
3. Hydraulic-oil tank

5.4P Cold weather maintenance includes:

1. Drain pump daily
2. Cover rear canopy openings

5.5A Chemicals can be used to control roots, odors, corrosion, rodents and insects.

5.5B Some people are reluctant to use chemicals to solve sewer problems because of past unfortunate experiences.

5.5C Doing nothing might be better than trying an untested chemical because even if the chemical didn't work, you might have to pay chemical costs and equipment and labor costs for application.

5.5D Metal chips and filings should not be put into a sewer because they will probably settle out in the sewer without reacting. If they do react, they will produce hydrogen gas which could produce an explosive mixture.

5.5E Before developing a testing program, calculate the cost per foot of sewer tested for buying and applying the chemical and testing the chemical to determine if it will be harmful to the wastewater treatment plant or a watercourse.

5.5F When roots are cut in a sewer, the roots will send out new growth just back from the cutting. Also the root will increase in diameter and break the pipe or open up the joint even more.

5.5G Before starting a chemical program for root control, obtain the following information from the manufacturer:

1. Recommend herbicide and EPA approval number.
2. Method of application.
3. Concentration and amount of chemical needed.
4. Contact time.
5. Preferred meteorological conditions.
6. Total cost for chemicals and application.
7. Hazards to downstream workers.
8. Effects on downstream wastewater treatment plant.
9. Effects on receiving waters of plant effluent.

5.5H Chemicals can be applied for root control by flooding, spraying, and foaming techniques.

5.5I Homes and businesses can become flooded during a chemical operation during the chemical contact period because the section being chemically treated is plugged off from the rest of the system. Wastewater will build up behind the plugged upstream manhole and could cause flooding.

5.5J Chemicals used for root control can be recovered and recycled by carefully moving the chemical operation down the sewer. After one contact period is over, plug the lower end of the next downstream section to be chemically treated. Release the chemicals from the upstream section and they will be "caught" in the downstream section. Also the chemicals can be pumped from one section into a tank and transported to the next section to be chemically treated.

5.5K When chemically treating roots, always read the label on the chemical container, wear protective clothing, and know what to do if an accident occurs.

5.5L Sources of grease in wastewater collection systems include restaurants, industries and homes with garbage grinders.

5.5M Odors from a wastewater collection system can be controlled by proper design, cleaning and maintenance methods.

5.5N Use of masking agents to overcome odors does not:

1. Correct the problem or cause of the odors, but
2. Masks the odor of hydrogen sulfide so you may not be aware of the presence of this toxic, flammable and explosive gas. Also hydrogen sulfide can be converted to sulfuric acid which is very corrosive.

5.5O Insects and rodents in a wastewater collection system should be controlled for the safety and protection of collection systems workers and the public.

5.6A Problems created by hydrogen sulfide include:

1. Paralysis of the respiratory center and death of workers.
2. Rotten egg odors.
3. Corrosion and possible collapse of sewers, structures and equipment.
4. Loss of capacity of sewer.

5.6B Hydrogen sulfide in sewers comes from the reduction of sulfate ($SO_4^=$) to sulfide ($S^=$) by bacteria in the slimes in sewers. Materials containing proteins in the wastes are an equally important food for bacteria that produce hydrogen sulfide. Any sulfur containing compound that is available as a food for slimes that reduce oxygen in the wastewater can produce odorous reduced sulfur compounds, including hydrogen sulfide.

5.6C Factors that are important in the production of hydrogen sulfide include:

1. Design
2. Cleaning procedures
3. Maintenance program
4. Materials
5. Slimes
6. pH
7. BOD
8. Temperature
9. Slope of sewer
10. Flow (full capacity?)
11. Velocity and turbulence
12. Age of system

5.6D Collection system maintenance has a definite effect on the rate of degradation of wastewater in the collection system. Undesirable impacts of degradation on the wastewater treatment plant include:

1. Odor and corrosion problems in plant facilities.
2. Initial or immediate oxygen demand on biological treatment processes.

5.6E Three potential methods of chemical control of sulfide include:

1. Chlorine
2. Hydrogen peroxide
3. Pure oxygen
4. Air
5. Lime for pH control
6. Sodium hydroxide for pH control

5.6F Chlorine is effective in controlling sulfide because it is toxic to aerobic bacteria that can cause anaerobic conditions and also toxic to organisms that convert sulfate to sulfide.

5.6G Hydrogen peroxide controls sulfide generation by:

1. Keeping wastewater aerobic (sulfide forms only under anaerobic conditions).
2. Combining with hydrogen sulfide to produce elemental sulfur.

5.6H Pure oxygen may be feasible to control sulfide in intercepting sewers when the wastewater treatment plant uses pure oxygen in the activated sludge process.

1. 2. 5. 10. 19. 20.
9. 3. 4. 6. 11. 23. 12. 18.
8. 7. 15. 13. 24. 21.
14. 16. 22.

OBJECTIVE TEST

CHAPTER 5. PIPELINE CLEANING AND MAINTENANCE METHODS

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

1. What causes stoppages in sewers?

   1. Roots
   2. Flushing
   3. Stoppers
   4. Adverse hydraulic conditions
   5. Grease

2. What items would you consider when selecting a solution to clear a stoppage in a sewer?

   1. Identify cause of stoppage.
   2. Tools and equipment available to clear stoppage.
   3. Add a solution to the upstream manhole to clear the stoppage.
   4. Urgency of clearing stoppage.
   5. Use of chemicals.

3. Emergency stoppages may be cleared by use of:

   1. Chemicals
   2. Grease
   3. Hand rods
   4. High velocity cleaners
   5. Power rodders

4. Roots may be removed from sewers by use of:

   1. Power rodders
   2. TV cameras
   3. Balling
   4. Flushing
   5. Pumping

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5. Odors from sewers may be controlled by use of:

   1. Perfume
   2. High velocity cleaner
   3. Balling
   4. Pure oxygen
   5. Chlorine

6. When should a wastewater collection system worker notify the operator of a downstream wastewater treament plant?

   1. When the supervisor is coming.
   2. When the high velocity cleaner is broken.
   3. After clearing a large septic stoppage.
   4. After quitting work for the day.
   5. None of these.

7. Hydraulic cleaning methods include:

   1. Power rodders
   2. Sewer scooters
   3. Power buckets
   4. Tires
   5. Balling

8. The purpose of an air gap device is to:

   1. Let the air flow
   2. Keep wastewater from flowing back into the water supply lines
   3. Allow a gap in the pipe
   4. Allow a gap for wastewater to flow out a manhole and not come in contact with a hose or pipe containing drinking water
   5. None of these

9. A sand or debris trap:

   1. Should be used with a high velocity cleaner
   2. Could be used with a rodding operation
   3. Has steel trap jaws
   4. Retards flow in the downstream manhole
   5. Should be used instead of shoveling debris if hydrogen sulfide gas is a problem in the manhole.

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10. How can the members of a balling crew communicate with each other?

  1. Shouting down the sewer
  2. Writing
  3. Sound powered telephones
  4. Hand signals
  5. Telegraph

11. The following precautions should be taken or at least considered before and during a balling operation:

  1. Care not to flood homes or businesses
  2. Try to avoid causing a stoppage downstream from the ball
  3. Proper routing of traffic
  4. Use of flagmen if necessary
  5. Three-worker crew if someone must enter a manhole

12. High velocity cleaning machines are used to do the following:

  1. Open stoppages
  2. Remove grease
  3. Clean lines of debris
  4. Increase velocity of wastewater flowing in sewer
  5. Wash manholes

13. Precautions taken with regard to operating a high velocity cleaning machine include:

  1. Care not to flood homes or basements.
  2. Avoid knocking out covers of cleanouts.
  3. Try not to allow nozzle to get stuck in sewer.
  4. Prevent the velocity from getting too high.
  5. Not allowing an inexperienced worker to operate the machine alone.

14. Flushing removes:

  1. Grit
  2. Grease
  3. Roots
  4. Heavy debris
  5. Light floatables

GO TO NEXT PAGE

15. What information should be contained in the record or log of a hydraulic cleaning operation?

    1. Type and amount of material removed from downstream manhole.
    2. Volume of water needed from fire hydrants.
    3. Traffic patterns.
    4. Amount of flow in sewer.
    5. Where obstructions were encountered.

16. Material is removed from a sewer by mechanical cleaning by:

    1. Scraping
    2. Sucking
    3. Cutting
    4. Sweeping
    5. Pumping

17. Basic tools used with power rodders include:

    1. Root saws
    2. Augers
    3. Corkscrews
    4. Spring blades
    5. Pruning shears

18. What factors must be considered when operating a power rodder?

    1. Use as much power as possible.
    2. Do not jam rodding tool into an obstruction.
    3. Do not rotate the rod.
    4. Do not rotate the rod in one position for extended periods.
    5. If a rod should break, make sure all the torque is out of it before handling it.

19. Why must you alwasy know where a cleaning tool is in a sewer?

    1. So you can locate it after a restbreak.
    2. So the tool can find its way back.
    3. So you know where obstructions or difficulties are encountered.
    4. So the tool can be located and dug up if it gets stuck.
    5. None of these.

GO TO NEXT PAGE

20. What is needed to keep cleaning equipment in good repair?

1. Temper
2. Time
3. Tolerance
4. Talent
5. Tools

21. Proper selection and application of chemicals in a wastewater collection system can be helpful to control:

1. Toxic pesticides
2. Roots
3. Rodents
4. Birds
5. Grease

22. When evaluating the application of chemicals to a problem in a sewer, remember that the chemicals:

1. Will travel down the sewer to a stoppage.
2. Are a permanent solution.
3. Perform the same in the field as in the lab.
4. Correct the source.
5. Require consideration of the safety of the workers and the public.

23. Steps to follow when developing a chemical testing program include:

1. Document claims and procedures in writing.
2. Compare cost of chemical program with other alternatives.
3. Photograph or video tape problems in test section before application of chemicals.
4. Agree in writing what results should be produced.
5. Keep good records before, during and after testing program.

24. Chemicals may be applied by which of the following techniques?

1. Calculating
2. Oxidizing
3. Flooding
4. Spraying
5. Foaming

GO TO NEXT PAGE

25. Before applying any chemicals, be sure to do the following:

1. Read the label on the chemical container
2. Study chemistry
3. Understand the type of chemical reaction that will occur
4. Know how to mix and apply the chemical
5. Be able to take the proper action if an accident occurs

26. Odor problems in wastewater collection systems usually result from:

1. Skunks
2. Rodents
3. Low velocities
4. High temperatures
5. Long transmission lines (sewers)

27. Rodents and insects can be controlled by:

1. Working with local health and/or animal control officials
2. Keeping manholes and sewers clean
3. Hoping they will go away
4. Spraying manholes with an approved pesticide
5. Waiting for the weather to change

28. Chemical control of sulfide includes the application of:

1. Hydrochloric acid
2. Hypochlorite
3. Hydrogen peroxide
4. Hydrogen sulfide
5. Lime

29. Why should hydrogen sulfide be controlled?

1. To protect workers
2. To prevent odors
3. To protect sewers and structures from corrosion
4. To prevent decay
5. To protect the environment in receiving waters

GO TO NEXT PAGE

30. *The amount of hydrogen sulfide produced in a sewer depends on:*

1. Amount of odor present
2. pH
3. Flow velocity
4. Temperature of wastewater
5. Anaerobic conditions

Review Questions

31. Why should flow velocities in sewers be measured in the field?

1. Velocities do not have to be measured in the field if velocities are shown on the plans.
2. To determine the actual velocity in a sewer.
3. To find out if solids might be settling out in the sewer.
4. To determine if a stoppage might be developing in the sewer.
5. To determine if the worker can calculate the flow velocity knowing the distance and travel time for a float or dye.

32. When reviewing plans and specifications,

1. Be sure there is sufficient overhead clearance for cranes where they might be needed.
2. Look for provisions for natural ventilation to reduce problems caused by gases found in sewers.
3. Be sure the engineer has calculated the flow velocities properly.
4. Determine if your existing maintenance equipment can be used in the new system.
5. Be sure traffic can be safely routed around manholes when necessary.

CHAPTER 6

UNDERGROUND REPAIR AND NEW CONSTRUCTION

by

William Puthuff, Jim Hicks, Mel Arts, John Dolenga,
John Cavoretto and Gene Turney

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OBJECTIVES

CHAPTER 6. UNDERGROUND REPAIR AND NEW CONSTRUCTION

After completion of Chapter 6 you should be able to do the following:

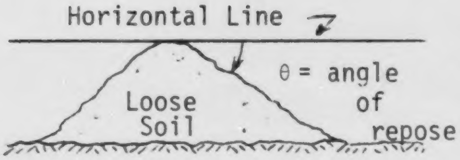
1. Safely repair or construct sewer lines and manholes.
2. Determine need for shoring and properly select and use shoring.
3. Describe shoring regulations.
4. Excavate, repair and backfill service lines.
5. Excavate, repair and backfill main lines.
6. Raise manhole frame and cover to grade.
7. Repair and install manhole bottoms.
8. Insert liners in sewers.
9. Seal leaky sewers by grouting.

GLOSSARY

ANGLE OF REPOSE

ANGLE OF REPOSE

The angle between a horizontal line and the slope or surface of unsupported material such as gravel, sand or loose soil. Also called the natural slope.



CROSS BRACES

CROSS BRACES

Shoring members placed across a trench to hold other horizontal and vertical shoring members in place.

EASEMENT

EASEMENT

Land owned by others in which a utility agency has a legal right to use the land to install and maintain a line, such as a sewer.

MAIN LINE

MAIN LINE

Branch or lateral sewers that collect wastewater from building sewers and service lines.

SHEETING

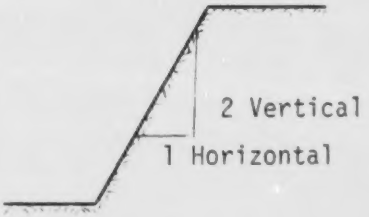
SHEETING

Solid material, such as wooden sheets or metal plates, used to hold back soil and prevent cave-ins.

SLOPE

SLOPE

The slope or inclination of a sewer or trench excavation is given as the vertical to the horizontal or "rise over run."



2:1 Slope

SPOIL

SPOIL

Excavated material such as the soil from the trench of a sewer.

STRINGERS

STRINGERS

Horizontal shoring members, usually square, rough cut timber, that are used to hold solid sheeting, braces or vertical shoring members in place. See WALERS.

SURCHARGE

SURCHARGE

Sewers are surcharged when the surface of the wastewater in manholes is above the top of the sewer pipe. The sewer is under pressure or a head, rather than at atmospheric pressure.

UPRIGHTS

UPRIGHTS

Vertical shoring members that may be solid (SHEETING) or spaced from 2 to 8 feet apart to prevent cave-ins.

WALERS

WALERS

Horizontal shoring members, usually square, rough cut timber, that are used to hold solid sheeting, braces or vertical shoring members in place. See STRINGERS.

CHAPTER 6. UNDERGROUND REPAIR AND NEW CONSTRUCTION

(Lesson 1 of 3 Lessons)

6.1 UNDERGROUND WORK

This chapter discusses repair and new construction of sewer service lines, main lines and manholes.

6.11 Safety Considerations

Underground work can be very hazardous. Whenever excavation is necessary to repair a sewer line or manhole, precautions must be taken to protect workers from cave-ins and also from dangerous gases and fumes. Precautions during excavation include adequate shoring and ventilation. Other safety considerations include protecting

1. Worker from traffic,
2. Public from injury,
3. Worker from injury,
4. Public and private property, including other utlities.

STOP
STOP
STOP
STOP

Also traffic must be routed safely around the job site. See Chapter 4, Section 4.1, Traffic and Manhole Safety for additional details.

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

MANHOLE SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:12 ON PAGE 4-14.

6.12 Types of Underground Work

Repair and new construction work consist of working on or installing service lines and manholes located on private property or streets and main lines and manholes located in rear easements and streets. Wastewater collection system repairs are necessary to correct damage to pipe or to remove an obstruction that is preventing the proper function of the collection system. Damage to pipe may occur through natural forces, but a large percent of repair jobs may be caused by poor design or poor workmanship during construction and later additions to the system.

6.13 Demand for Repair

A request to repair a line may originate from a user who is not being provided service due to collection system failure or from the agency's inspection or preventive maintenance units.[1] If the request for repair originates from an agency's emergency service crew, they may have restored service and in so doing discovered a damaged pipe that must be repaired or an obstruction that must be removed.

Work request forms (see Section 6.15) provide an organized approach for other crews to notify a repair crew that a line needs repairs. Whenever an emergency crew, TV inspection crew, or preventive maintenance crew discovers a situation needing repair, a work request form is completed and delivered to a supervisor. The supervisor reviews work requests and assigns them to a repair crew. Examples of various types of defects located and identified by emergency crews or preventive maintenance crews are given in the following sections.

6.14 Sources of Damages and Stoppages

Sewer lines may have to be dug up because they are damaged or blocked. Causes of these problems are described and shown in this section.

---

[1] Preventive maintenance units. Crews assigned the task of cleaning sewers (for example balling or high velocity cleaning crews) to prevent stoppages and odor complaints. Preventive maintenance is performing the most effective cleaning procedure, in the area where it is most needed, at the proper time.

6.141 Roots

Roots often enter pipes through cracks and cause stoppages. Figure 6.1 shows a cracked pipe that was dug up with roots growing around it. Probable cause of pipe damage in Fig. 6.1 is improper bedding (such as large stones) that caused pipe to crack and allowed roots to enter the pipe. These roots may prevent inspection or cleaning equipment from passing through a sewer.

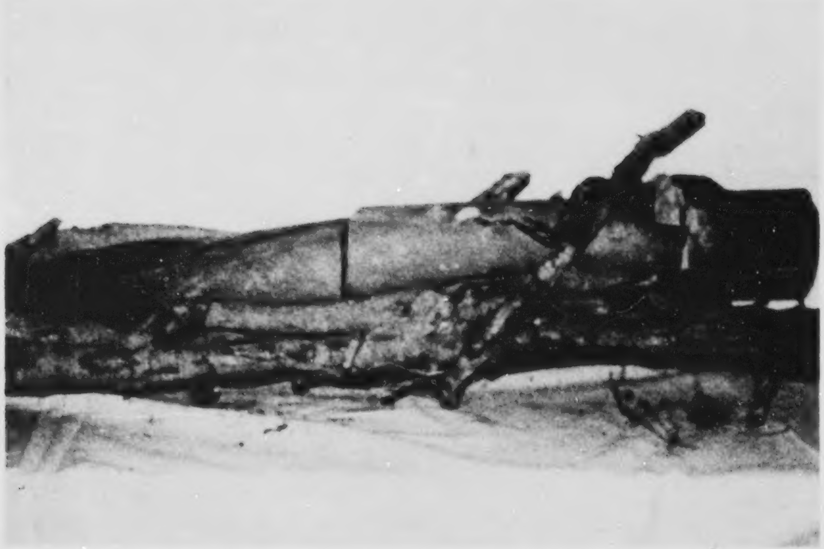


Fig. 6.1. Cracked pipe.

6.142 Improper Taps

Improper taps prevent either building and/or branch and lateral sewers from functioning as intended. Various types of improper taps include:

1. Protruding taps.
2. Cracks or holes that allow root entry, leaks and concrete to enter the sewers.
3. Insufficient opening in tap.
4. Misalignment of tap.

A tap protruding into a main line can cause material to build up and stop the flow in the main line (Fig. 6.2). Also it can prevent inspection and cleaning equipment from passing by the tap. To repair a protruding tap, remove a section of the main line containing the tap and install a factory made wye or tee and connect it to the building sewer. A protruding tap may be prevented by cutting a hole in the main line with a can type cutter and installing a proper saddle.

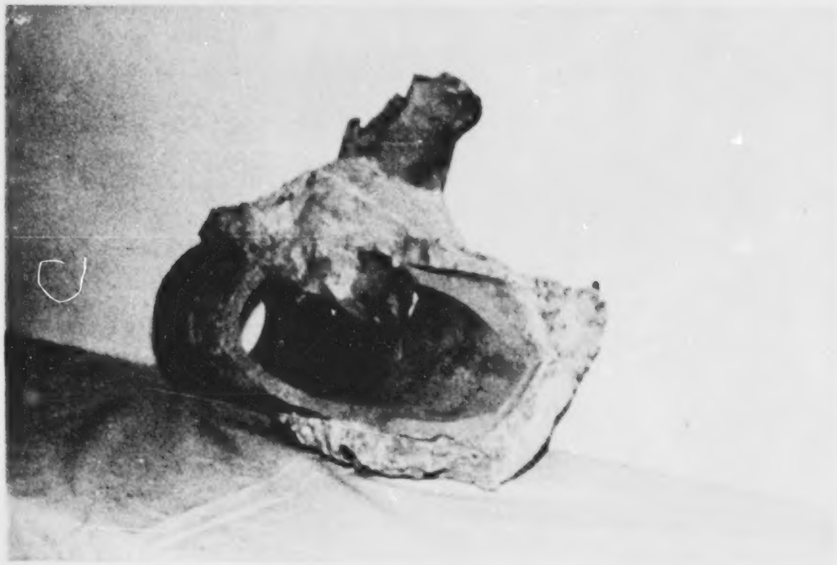


Fig. 6.2. Protruding tap.

An improper tap cut in a main line can allow cement to flow inside the main line during installation and cause problems in the future (Figs. 6.3 and 6.4). Cracks, holes or pipe broken at tap allow root intrusion, infiltration, and exfiltration.

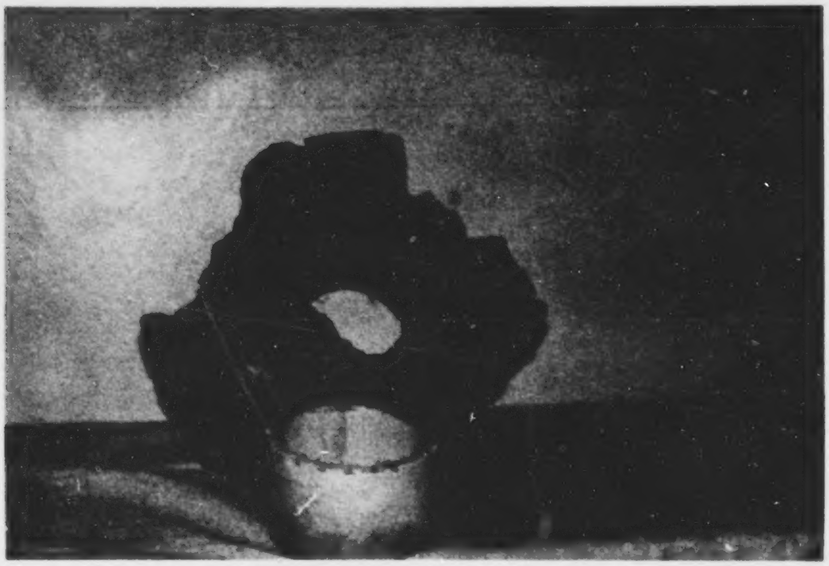


Fig. 6.3. Improper tap. Note cement in main line.

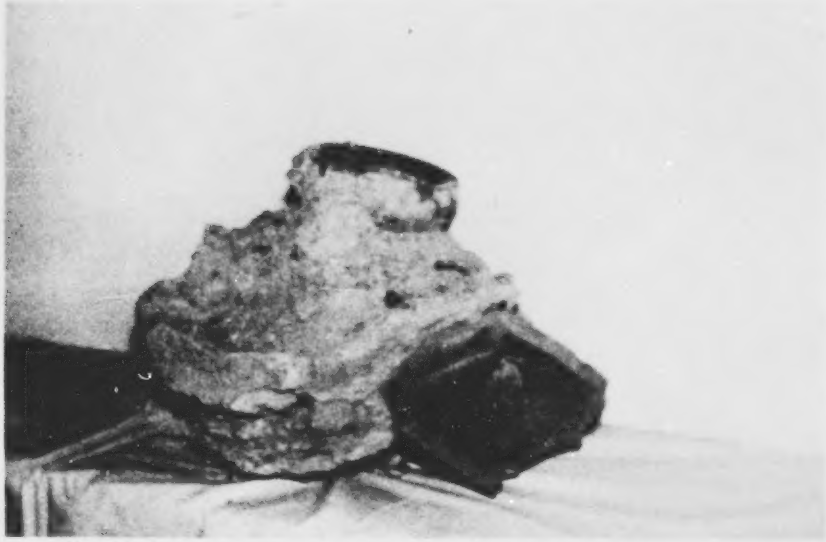


Fig. 6.4. Improper tap. Note cement poured around tap.

6.143 Damage by the Public or Other Utility Agencies

Other utility agencies or the public can cause damage by underground construction, illegal taps or vandalism. Figures 6.5 and 6.6 show drain pipes from yard and gutters installed by a homeowner. Other agencies can run lines and ducts through sewer lines. Borings for foundation tests can penetrate sewer lines. Also telephone pole and guy wire augers can damage sewers.

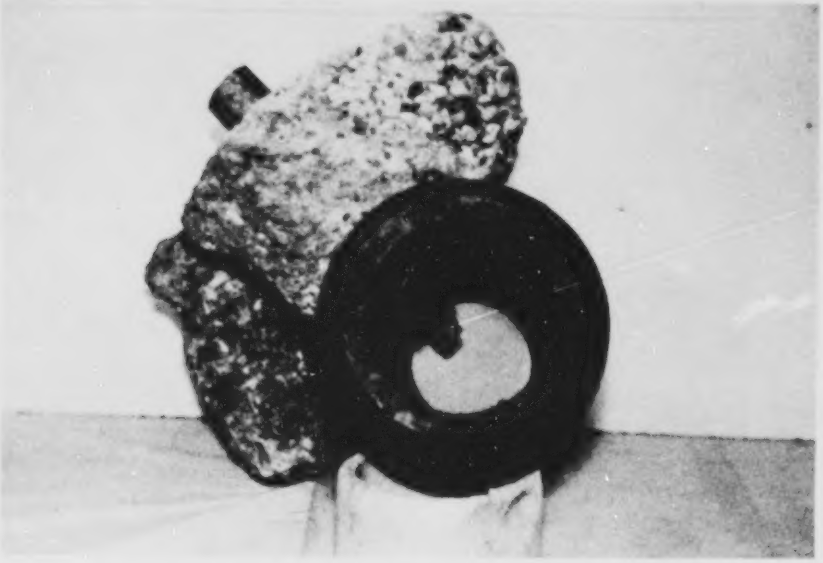


Fig. 6.5. Illegal drain tap.

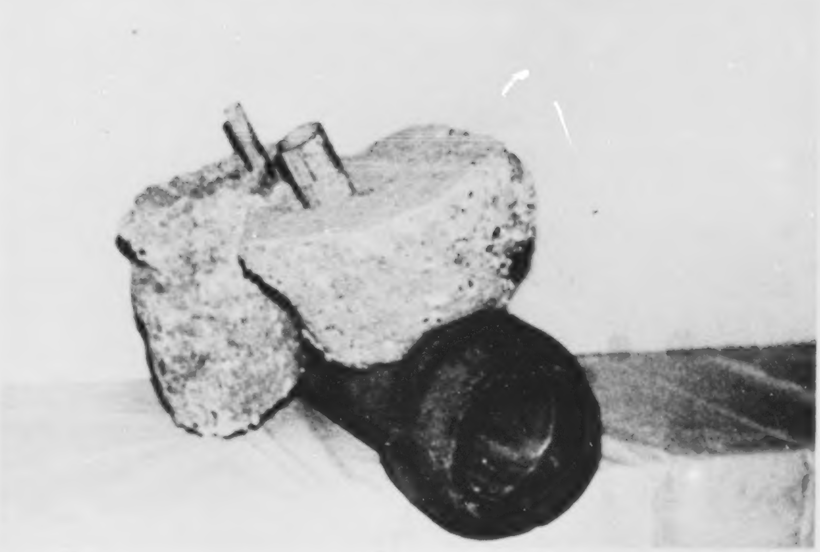


Fig. 6.6. Illegal drain tap.

6.15 Work Request Form

Upon discovery of a sewer line needing repair, a work request form should be completed (Fig. 6.7). Information on the form is essential for establishing repair priorities and scheduling work. The work request form should provide the following information:

1. Name of crew chief
2. Date
3. Street address near requested repair
4. Map location
5. Manhole numbers on each side of damaged pipe
6. Size of pipe
7. Depth of pipe
8. Distance from upstream manhole to damaged pipe
9. Location of pipe (street or easement)
10. Work requested.

6.
7. Five feet,
8 Seven feet,
9. Sierra View
10. Fix!

Crew Chief SWANSON Date 9-26-73
Address MARCONI AVE. Book 269 Page 05
Manhole 8 to 7
Pipe Size 6" VCP Depth 6'9" - 9'8" Distance 292
Street ☐ Easement ☒

Work Requested REPLACE TAP w/ROOTS

27' FROM M/H 8 → 7

PIC. #1

M/H 8 LOCATED AT 3609 MARCONI AVE.

Approved'

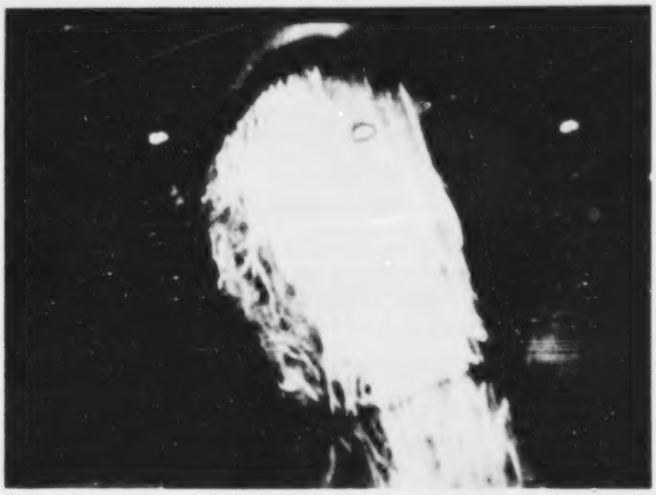


Fig. 6.7. Work request form and photo of roots in tap that must be removed and replaced.

6.16 Assignment of Repair Job

When the repair or construction supervisor (maintenance supervisor) receives the work order form, the supervisor reviews the job and assigns it to a foreman or crew leader. If work loads are heavy, the foreman may assign a priority to work orders. Those repairs that are not urgent may be given a low priority and the work is done at a later date. When a foreman is assigned a work order, the job should be evaluated and the crew prepared to accomplish the repair job.

6.161 Investigate and Plan Job

Before starting a repair job, the foreman or supervisor in charge of the work should investigate the job site and plan the work. The foreman or supervisor should make notes on conflicts with utilities, traffic patterns, parked vehicles, or private property that might have to be moved, such as trees or fences, and soil conditions if known.

6.162 Meet with Utility Companies

All utility companies in the area should be contacted. Each company should meet the foreman at the job site and locate and mark utilities buried near the work area. Some underground utility companies are so small that their personnel cannot come out to the site and mark locations. If this occurs, inspect their maps in their office and do your own marking of the utilities. Utility companies will not accept responsibility for damage unless their workers located their utilities. Most companies insist their workers be on the job site until their facilities are uncovered and no conflict exists. When all underground utilities are located and marked, some thought should be given to overhead utility conflicts. The type of equipment used on the job depends on the potential problems encountered when doing the job.

6.163 Public Relations

Contact should always be made with the property owners in the area making them aware of any inconvenience that might occur. If excavation is going to block a drive-way into a business, contact the owner or manager and try to schedule your work so little or no conflict will exist. Good public relations are very important and should be considered at all times.

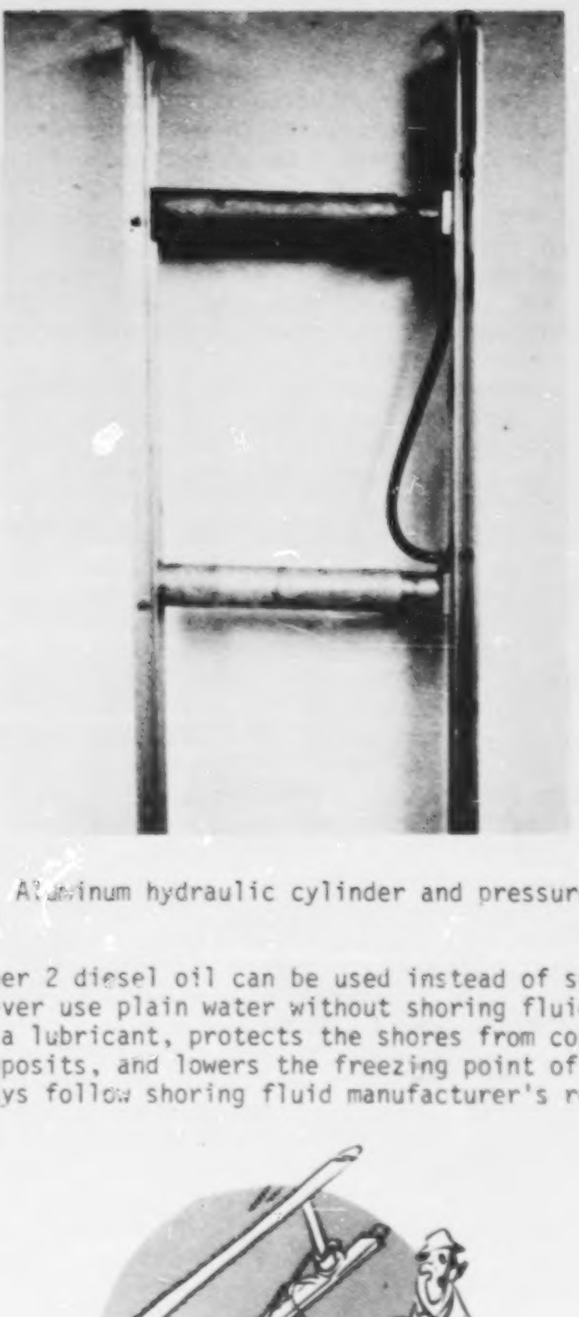


Fig. 6.13. Aluminum hydraulic cylinder and pressure hose.

Undiluted Number 2 diesel oil can be used instead of shoring fluid and water. Never use plain water without shoring fluid. The shoring fluid acts as a lubricant, protects the shores from corrosion damage and mineral deposits, and lowers the freezing point of the liquid mixture. Always follow shoring fluid manufacturer's recommendations.

6.164 Preconstruction Meeting

A tail gate safety and preconstruction meeting should be held with all workers on the project (Fig. 6.8). Discuss what is to be accomplished and the duties of each person. What is to be accomplished means telling the crew what repair is necessary, such as a tap replacement, cleanout installation, or main line repair. The duties of each person will be the usual work assignment, unless special tools or materials are required for the specific job assignment. The preconstruction discussion is on what to expect and what to do if the unexpected occurs.

Fig. 6.8. Tail gate safety and preconstruction meeting.

All safety regulations and work procedures for the particular job should be thoroughly explained. The notes taken by the foreman are valuable and should be used at this time. Worker's safety, pedestrian safety, and underground conflicts should be thoroughly reviewed so there will be no surprises when the crew arrives on the job site and starts to work. For more information, read Chapter 9, Section 9.82, Tail Gate Sessions.

QUESTIONS

6.1A Why are underground repair and new construction very hazardous?

6.1B Why is underground repair necessary?

6.1C How are underground damages discovered?

6.1D What are some causes of damages and stoppages that require underground repair?

6.1E What is the purpose of a work request form?

6.1F What should a foreman do before starting a repair job?

6.2 SHORING

Whenever excavation is necessary for repairs or new construction, shoring may be necessary to protect workers from cave-ins. The need for shoring and shoring requirements depends on many factors, such as, depth of trench, width of trench, type of soil (clay, loam, sand), soil conditions (compaction, moisture) and nearby activities that could cause vibrations. Shoring requirements are dictated by laws and codes and are strictly enforced by the regulatory agencies. Lack of shoring or shoring failure are the major causes of underground construction deaths. For example, seven workers died and there were 67 lost-time injuries related to construction shoring problems in California during 1973. By comparison, there were no deaths and 203 lost-time injuries to workers in the wastewater collection works field. How can we prevent these accidents? First learn the shoring laws and codes, types of shoring, proper use, and then apply this knowledge. Also develop a safety program and an approved OSHA (Occupational Safety and Health Act) shoring class. The Williams-Steiger Occupational

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Safety and Health Act (OSHA) of 1970 contains shoring regulations, and they are strictly enforced. Penalties for violating the regulations include warnings, fines and even prison sentences for flagrant violations. Contact your local safety office for all regulations pertaining to any excavations done by you or your crews. For additional information, read Chapter 3, Section 3.51, Excavations and Shoring, and Chapter 9, Section 9.4, Excavations and Trench Shoring.

"SAFETY
APPROVED
OSHA
SHORING
REGULATIONS

6.21 Shoring Requirements

Typical shoring requirements include:

1. Shoring systems in trenches shall consist of uprights held rigidly opposite each other against the trench walls by jacks or horizontal cross members (cross braces) and, if required, longitudinal members (stringers) as hereinafter provided. Uprights shall not exceed 15 degrees from the vertical.

2. Uprights in trenches over 10 feet deep shall be not less than 3-inch by 8-inch material, and shall be at least 2-inch by 8-inch material in trenches less than 10 feet deep. (See Table 6.2 under (5) on page 6-15 for additional details and for requirements applying to running ground).
   Uprights shall extend from above the top of the trench to as near the bottom as permitted by the material being installed, but not more than 2 feet from the bottom.

3. Cross braces shall consit of steel screw-type trench jacks with a foot or base plate on each end of pipe or timbers placed horizontally and bearing firmly against uprights or stringers. Wood braces shall be no smaller than those listed in Table 6.1.

TABLE 6.1. SIZES OF WOOD AND PIPE BRACES IN TRENCHES[a]

Width of Trench Feet (Incl.)	Size of Wood Braces	Size of Pipe Braces	Aluminum Hydraulic Shores
1-3	4" x 4"	1 1/2" STD	2"
3-6	4" x 6"	2" STD	2"
6-8	6" x 6"	2" STD	2"
8-10	6" x 8"	3" STD	2"
10-12	8" x 8"	3" STD	3"

Wider trenches shall have cross braces of correspondingly larger dimensions.

a. Consult with your local safety agency for sizes of wood and pipe cross braces required in your area.

NOTE: In lieu of the above shoring systems, the use of properly maintained screw-type metal jack trench shoring units with equivalent strength is acceptable (Fig. 6.9).

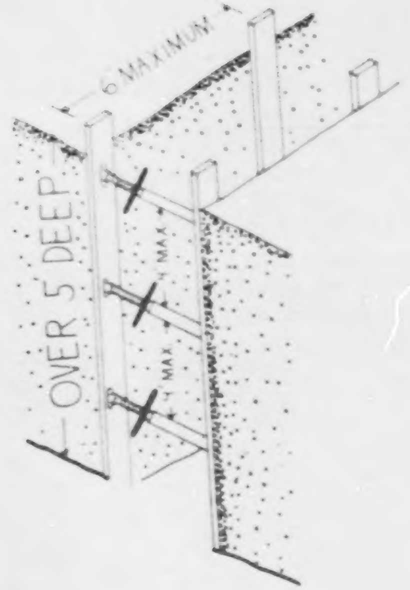

Fig. 6.9. Use of screw-type metal jack trench shoring units.

4. The minimum number of horizontal cross braces, either screw jacks or timbers, required for each pair of uprights shall be determined by the number of 4-foot zones or segments into which the depth of trench may be divided. One horizontal cross brace shall be required for each of these zones, but in no case shall there be less than 2 cross braces or jacks. Trenches, the depths of which cannot be divided equally into these standard 4-foot zones or segments, shall have an extra horizontal cross brace supplied for the short remaining zone, if such zone is greater than two feet. In no case, however, shall the vertical spacing of horizontal cross braces be spaced greater than 5 feet center to center. Minor temporary shifting of horizontal cross bracing will be permitted, when necessary, for the lowering of materials into place. Be sure no one is allowed in the trench while the cross braces are temporarily shifted or moved. If the diameter of a pipe is greater than four feet, the lower cross braces require alternate considerations.

5. The dimensions and spacing of the elements of the shoring system shall be governed by the depth of the trench, type of soil encountered, and other special conditions of the site, but in no case shall they provide less strength than the members listed in Table 6.1 and 6.2. These dimensions and spacings are to be considered as a minimum requirement.

QUESTIONS

6.2A Shoring requirements depend on what factors?

6.2B What is the number one cause of cave-in deaths?

6.2C What do shoring systems in trenches consist of?

6.2D Uprights shall extend how close to bottom of trench?

6.2E How is soil stability classified?

TABLE 6.2. DIMENSIONS AND SPACINGS OF ELEMENTS OF SHORING SYSTEM

Soil Stability	Depth	Uprights		Cross Braces		Stringers	
	Feet	Size, Inches	Horizontal Spacing, Feet	Size, Inches	Horizontal Space, Feet	Size, Inches	Vertical Spacing, Feet
Hard, compact --	5-10	2 x 8	8	4 x 4	8	Where indicated	
	Over 10	3 x 8	6	4 x 6	6	Where indicated	
Unstable--------	5-10	2 x 8	4	4 x 4	4	Where indicated	
		2 x 8	2	4 x 4	2	Where indicated	
	Over 10	3 x 8	Solid	4 x 6	6	4 x 6	4
Running---------	4-8	2 x 8	Solid	4 x 4	6	4 x 6	4
	Over 8	3 x 8	Solid	6 x 6	6	6 x 6	4

Soil Stability may be classified as hard compact, running or unstable.
Hard compact soil is all earth material not classified as running or unstable.
Running soil is earth material whose angle of repose[a] is approximately zero, as in the case of soil in a nearly liquid state, or dry, unpacked sand which flows freely under slight pressure.
Unstable soil is earth material that has a significant angle of repose, but because of vibration, moisture or other reasons, cannot be depended upon to remain in place without extra support.

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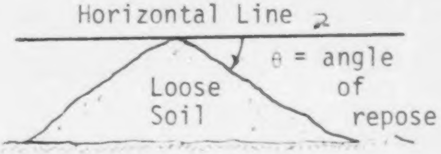
[a] Angle of repose. The angle between a horizontal line and the slope or surface of unsupported material such as gravel, sand or loose soil. Also called the natural slope.



6.22 Responsibility

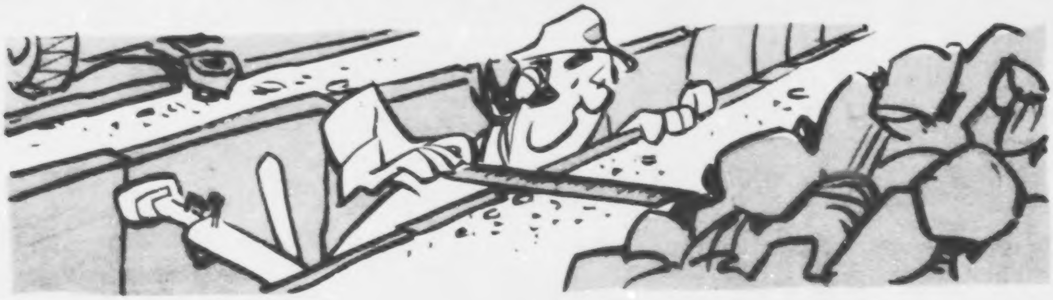
All excavation work shall at all time be under the immediate supervision of someone (such as a foreman or crew leader) with authority to modify the shoring system or work methods as necessary to provide greater safety. This person will frequently examine the material under excavation and improve the shoring or methods beyond the minimum requirements, as necessary to insure protection of workers from moving ground. Improved shoring or methods may be required if there is evidence of excessive shifting, displacement, or removal of cross bracing.

Someone must be on the job site and in charge at all times. This person not only accepts responsibility, but is authorized to change any predetermined shoring systems when soil conditions change. Material handling, traffic pattern changes, public relations, repair work excavation, backfill and compaction are directed by the person in charge. Some of the listed jobs will have to be delegated or they won't be done effectively.

Tail gate safety meetings and the preconstruction meetings are very important. Everyone on the job site must know exactly what to do and what is expected to be accomplished.

6.23 Placing of Spoil[2]

For trenches less than five feet in depth, the spoil (excavated material) should be placed two feet or more back from the edge of the trench (Fig. 6.10). Trenches over five feet in depth should have the spoil placed four feet or more back from the edge of the trench. Try to keep the area between the trench and the spoil area clear of loose



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[2] Spoil. Excavated material such as the soil from the trench of a sewer.

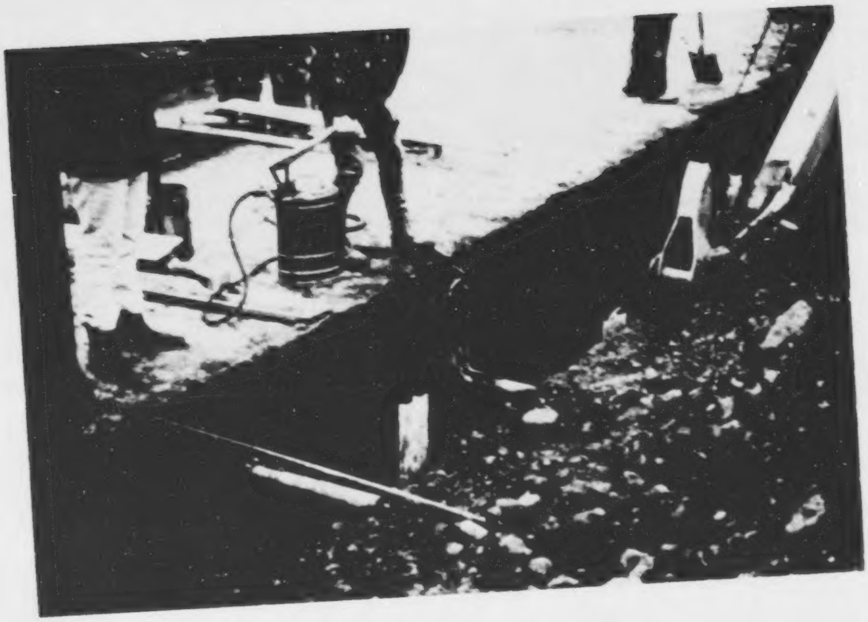

Fig. 6.10. Keep area near trench clear.

This photo shows two unsafe conditions:

1. Shores do not extend above the ground surface.
2. Spoil is too close to edge of trench.

material. If not kept clear, material such as rocks, tools and pipe could be knocked into the excavation, or someone could trip on the equipment and fall into the trench. Keeping the area clear is not only good for the safety of workers, but reduces the chances of damage to new pipe or other conduits and utilities which could cause thousands of dollars worth of damages. Also keeping spoil away from the edge of the trench tends to reduce the load on the side walls, thus reducing the loads on the sheeting, uprights, stringers and cross bracing.

6.24 Shoring Regulations[3]

6.241 Worker Safety

All trenches five feet in depth and deeper must be effectively shored to protect workers against the hazard of moving ground. Trenches less than five feet in depth also must be shored when examination indicates hazardous ground movement may be expected.

Special provisions must be made to prevent injury to workers engaging in installation of shoring. This may be done by providing and requiring the use of special devices such as long handled jacks that will allow upper cross braces to be placed from the ground surface before workers enter the trench. At those points in deep trenches requiring additional braces, workers shall then progress downward, protected by cross braces that have already been set firmly in place. Reverse procedure shall be followed when removing shoring.

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[3] These regulations are from the State of California's Division of Industrial Safety, Construction Safety Orders, Title 8, Subchapter 4, Article 6. Other states have similar regulations. You should contact your state industrial safety officer to obtain the shoring regulations for your state.

6.242 Soil Conditions and Trench Location

The type of shoring installed depends on the soil conditions and the location of the trench. You cannot shore an excavation alongside a railroad track the same as one in an open area because of vibrations created by passing trains (Fig. 6.11). When the decision is made on the type of shoring to use, remember soil conditions change and an alternate shoring system should be readily available so little work time will be lost if a change must be made.

6.243 Sloping Excavation Walls

In lieu of a shoring system, the sides or walls of an excavation may be sloped if this method is considered more economical and the job can be done safely. Where sloping is a substitute for shoring, that would otherwise be needed, excavation side walls should be on a slope of 3/4 foot horizontal to one foot vertical except where the instability of material requires a slope of greater than 3/4 :1 (3/4 vertical to 1 horizontal).[4] Read Chapter 3, Section 3.514, Trench Shoring, for more details.

6.244 Access to Construction Work Area

Convenient and safe means must be provided for workers to enter and leave the excavated area. Access shall consist of a standard stairway, ladder or ramp securely fastened in place at suitably guarded or protected locations where people are working and usually ladders are less than 100 feet apart.

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[4] Slope of 3/4 :1.

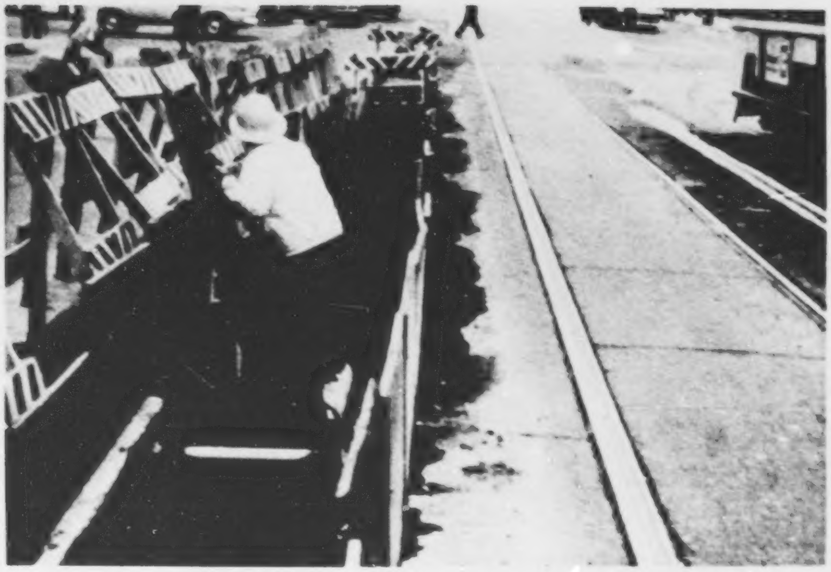

Fig. 6.11. Shoring alongside a railroad track.

6.245 Pedestrian Safety

When working near curbs and sidewalks, keep a pedestrian way open on the sidewalks. If this area becomes covered with material and equipment, the pedestrians will be in the work area or walking across someone's yard. Neither one of these situations is acceptable. If necessary, erect barriers to keep pedestrians and children in safe, permissible areas. Be especially careful if children are playing or watching near the job site.

QUESTIONS

6.2F What should be the authority of someone supervising excavation work?

6.2G Where should spoils or excavated material be placed?

6.2H All trenches deeper than _____ feet must be shored.

6.2I How can workers be protected if shoring is not practical?

6.2J Why must a walkway be provided for pedestrians?

6.25 Types of Shores

There are several types of shores that have been tested and approved by OSHA. Each type of shoring has its good and bad points. Selection of types of shoring depends largely on soil conditions in your area.

6.251 Hydraulic Shores

Hydraulic shores are used frequently due to their ease of installation and removal. They are usually not used on jobs when they will be required to be left installed in one segment of trench for a time period greater than five days due to the possibility of the hydraulic pressure bleeding off during a longer period of installation.

The standard aluminum hydraulic cylinder (Fig. 6.12) is 2 inches in diameter. Each shore has two cylinders and two 7-foot rails equal in strength to 3"x10" timbers. Each rail is 8 inches wide and 1 1/2 inches deep. The complete unit weighs 70 pounds and can spot-brace trenches 22 to 48 inches wide. The two cylinders are connected by a high-pressure, flexible hose that allows fluid to be pumped into the cylinders to expand them to the desired length (Fig. 6.13). Recommended fluid to use in hydraulic shores is one quart shoring fluid (water soluble oil) to 19 quarts water for each five gallon mixture.

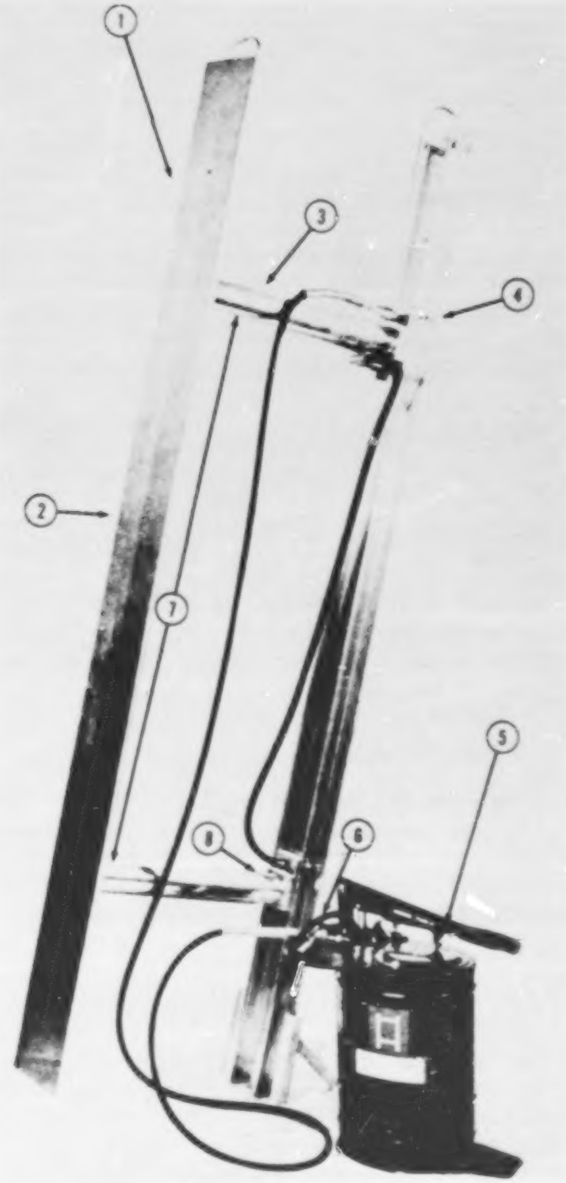

Fig. 6.12. Aluminum Hydraulic Cylinder

(Courtesy of SPEED-SHORE)

1.	Aluminum alloy material	5.	Pump
2.	Flanged siderail	6.	Pressure gage
3.	Hydraulic cylinder	7.	4-foot cylinder spacing
4.	Offset pins connecting siderails and hydraulic cylinders	8.	Cylinder pad

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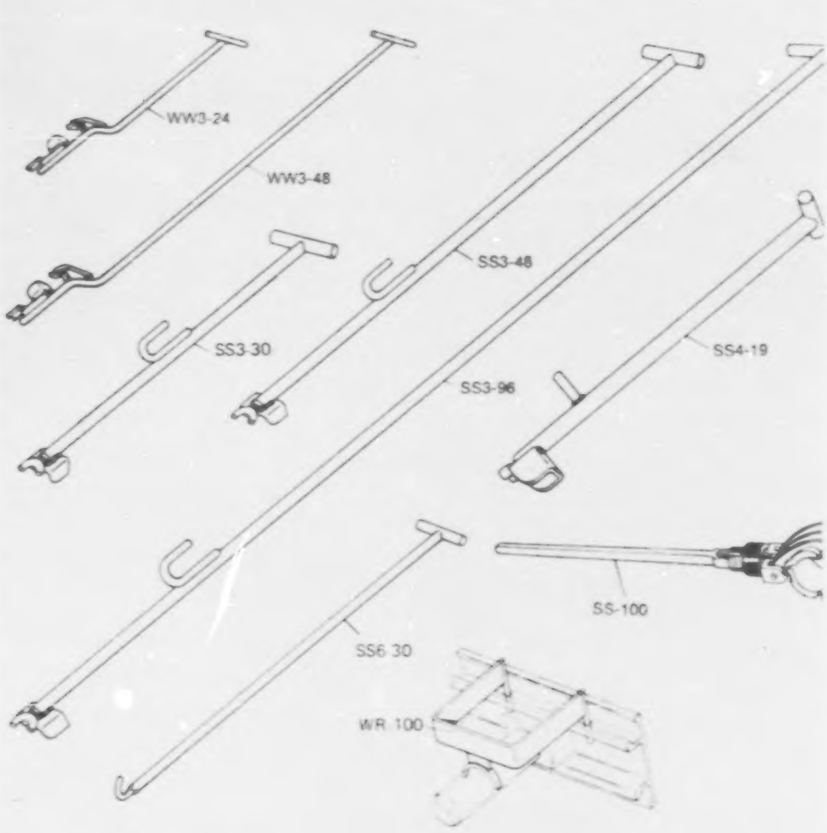
Installation of the standard hydraulic shore is usually a one worker operation. Place shore across trench with one rail on top of the other in the trench. Connect pump hose to male fitting on shore (top cylinder). Open valve on pump. The installation tool (Fig. 6.14) is from 30 to 96 inches long depending on depth of trench in which you are installing the shores. This tool is approximately a one-half inch diameter steel rod with a tee handle on one end, a hook and pressure release on the other end. This tool is hooked on to the side rail of the shore and held firmly with the other hand, grasp handle on the opposite side rail and lower shore into trench. When desired position of shore is reached, close valve on pump and start pumping by raising and lowering pump handle (Fig. 6.15). When desired pressure is reached, usually 750 to 1000 pounds per square inch, disconnect hose from cylinder by using lower end of installation tool. Open valve on pump to relieve pressure in hose. Coil hose around pump to keep connecting end free of dirt and sand. Move pump to next installation and repeat the procedure at the prescribed intervals shown in Table 6.2.

The two-inch cylinder can be reinforced with square steel tubing and extensions used to shore trenches up to 14-feet wide. For excavations from 10 feet up to 24 feet in width, the three-inch aluminum hydraulic cylinder is used. If you do not have experience shoring trenches 10 feet and wider, obtain correct information and engineering advice before starting the project. Improper shoring materials can be very costly on trenches or excavations of this size.

6.252 Screw Jacks

Screw jacks (Fig. 6.16) are time consuming to install and usually are not used on large production jobs. They are inexpensive to purchase; and for minor repairs in smaller excavations, they are more practical than other types of shores. Screw jacks must be placed from top down, and those who have used them know this is a slow process. Screw jacks are made of iron and come in two pieces. They are available with a 1 1/2 or 2-inch threaded shaft and wing nut that is used for adjustment to fit trench width. One end of the shaft is plain and the other has a ball-socket for a shoe that goes against the shoring. The screw length on the 1-1/2 inch shaft varies from 10 to 18 inches. The 2-inch shaft has a screw length of 18 inches only.


WW3-24
WW3-48
SS3-48
SS3-30
SS3-96
SS4-19
SS-100
SS6 30
WR 100

SPEED SHORE ACCESSORY PARTS LIST

Part No	Description	Part No	Description
SS3-30	Speed Shore Release Tool [illegible]	SS6-96	Removal Hook [illegible]
SS3-48	Speed Shore Release Tool [illegible]	WW3-24	[illegible] Release Tool [illegible]
SS3-96	Speed Shore Release Tool [illegible]	WW3-48	[illegible] Release Tool [illegible]
SS4-19	Single Shore Release Tool [illegible]	SS-100	Speed Shore [illegible]
SS6-30	Removal Hook [illegible]	WR-100	[illegible]
SS6-48	Removal Hook [illegible]*		

* Not pictured

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Fig. 6.14. Installation and release tools
(Courtesy of SPEED-SHORE)

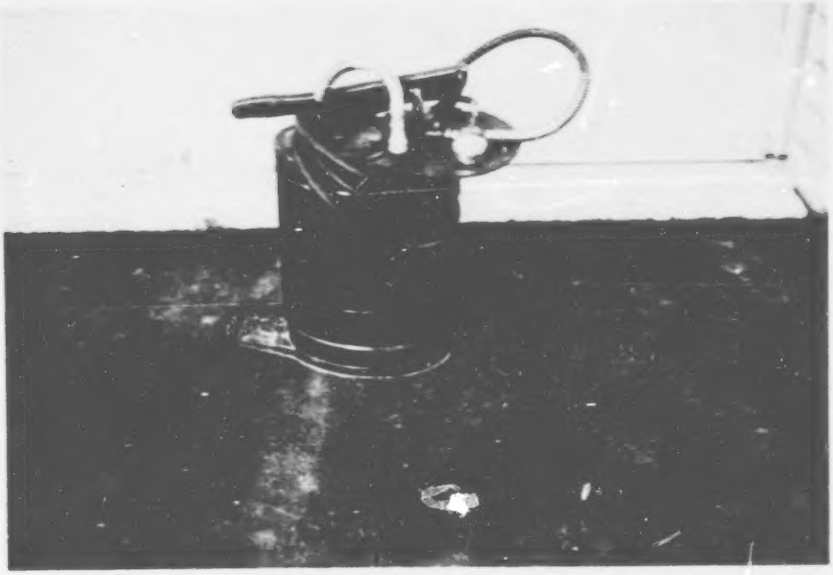

Fig. 6.15. Pump for hydraulic cylinder.
(See Fig. 6.12, item 5, pump)

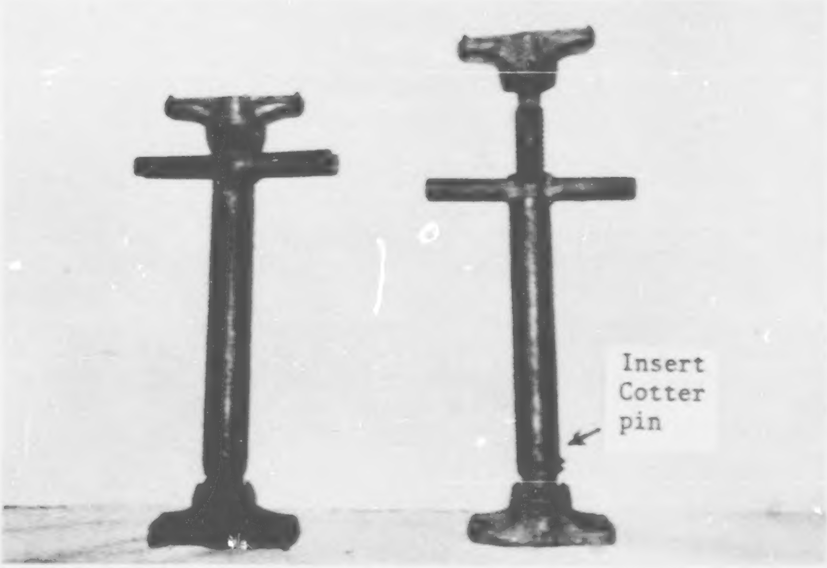
Insert
Cotter
pin

Fig. 6.16. Screw jacks

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The other part of the screw jack consists of a shoe and ball joint with a male fitting to fit inside a 2-inch pipe. This fitting has a hole to secure the desired length of pipe to it. Cut the length of pipe required, usually about 8 inches shorter than the trench width. Drill a hole through one end large enough to accept a cotter pin. All jacks should be assembled before excavation is started. Extra pipe should be available if needed. The weight of each jack varies from 13 to 23 pounds, depending on length of pipe used. Installation of the screw jacks usually requires two workers. The hydraulic jacks have rails for the cylinders to push against. The screw jacks have none, so timbers must be used (Fig. 6.17). Vertical members of the shoring in trenches less than 10 feet deep use a minimum of 2 x 8 rough timbers. In trenches over 10 feet deep, use a minimum of 3 x 8 rough timbers. Timbers should be Douglas Fir or equal. Always use full cut and rough dimension timbers. See Table 6.2, page 6-15, for additional details and requirements applying to "running" soil conditions.

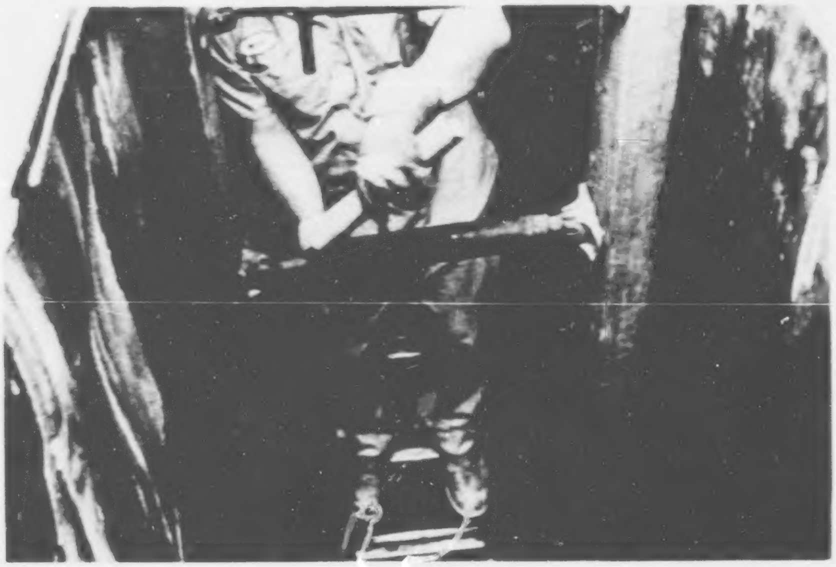

Fig. 6.17. Screw jacks with timber uprights.

WARNING - Never use jacks for access ladders. Always use a ladder.

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Two workers are needed to install screw jacks. One worker holds the vertical timbers and the other installs the screw jacks. Begin installing screw jacks at the top of the trench and no more than two feet down from top. The first jack is placed in the trench and the wing nut screwed out against the pipe until enough pressure is applied to hold the timbers in place. Spike a 16-penny nail through the shoe to hold jack and timber in place (Fig. 6.18). When installing jacks from top to bottom, the upper jacks tend to loosen up; and if they are not secured with a nail, they might fall on the worker installing the bottom jack. When all the jacks are in place, tighten them until the vertical timbers (uprights) are flush against the walls of the trench (Fig. 6.19). Each jack should be pushed against the uprights with a similar force. Good judgement must be used to determine when screw jacks are tight enough.

6.253 Air Shores

Air shores (Fig. 6.20) are new by comparison to the other shores discussed. They are a pneumatic shoring cross brace made for trenches where shoring is required.

Air shores are not equipped with rails like hydraulic shores. They are used similarly to screw jacks and are used only as the cross brace which can be rapidly set to hold shoring members in place.

Five sizes of air shores are designed for various trench widths and excavations. The 18 to 27-inch span air shore weighs ten pounds.

The largest air shore has a 60 to 96-inch span and weighs 30 pounds. Air shores are activated or expanded by compressed carbon dioxide (CO_2) gas.

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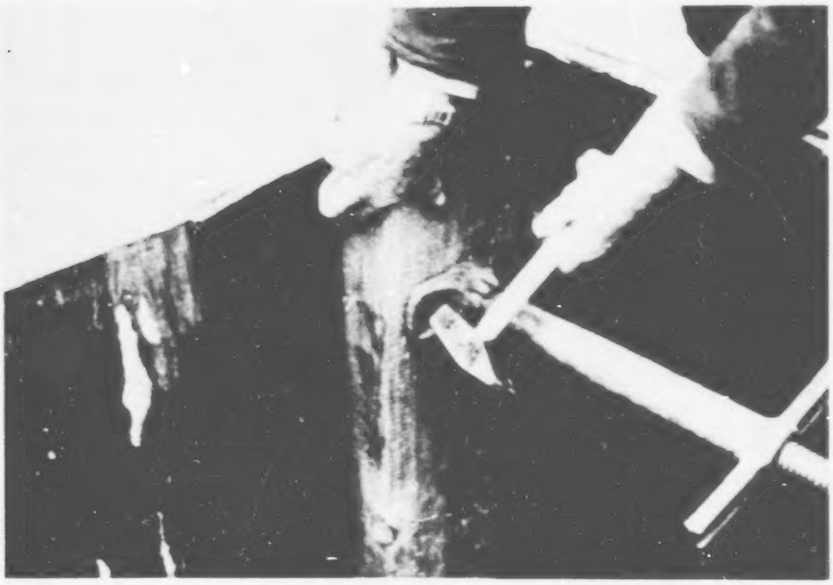

Fig. 6.18. Shoe of screw jack being nailed into place.

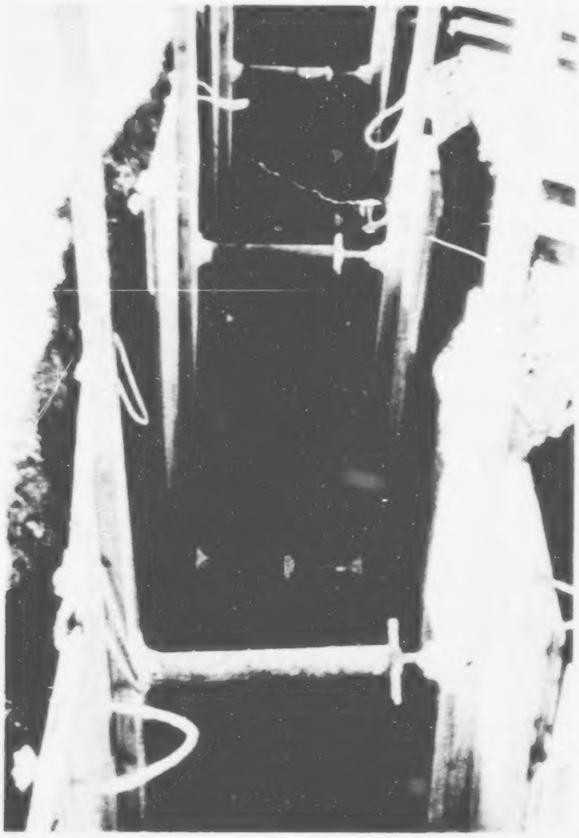

Fig. 6.19. Screw jacks holding vertical timbers or uprights against wall.

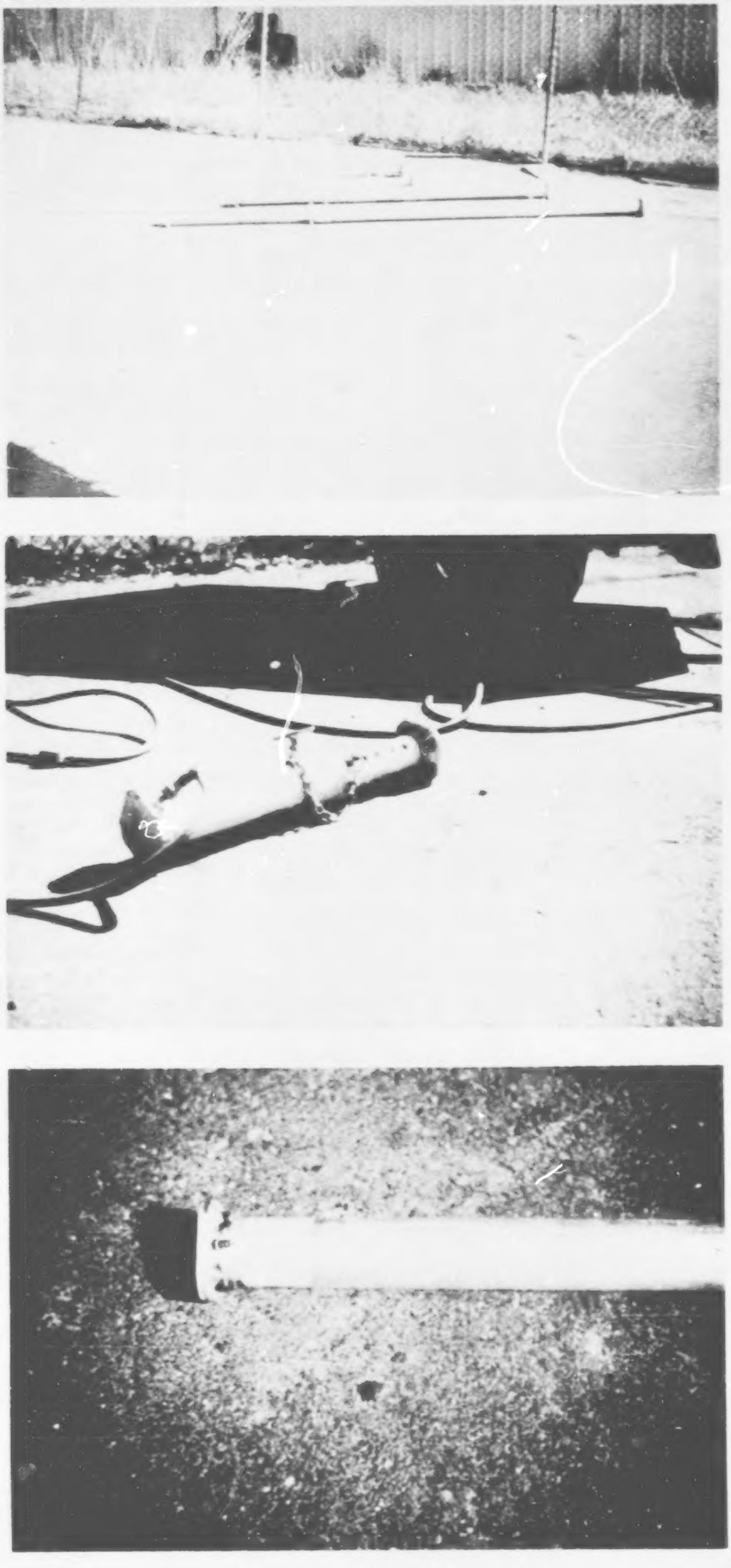

Fig. 6.20. Air Shores

To install or remove air shores requires two workers. One or two additional workers are needed to hold the sheets and braces in place on each side of the trench while the air shore is being installed. The shore is held in place or positioned by one worker. The other person actuates the carbon dioxide valve and expands the air shore ram against the shoring to a pressure of 200 to 300 psi. When the shore has been expanded, the worker positioning the air shore rotates the locking collar and inserts a pin behind the locking collar and through the ram to form a mechanical lock. The carbon dioxide is then bled off from the ram and the air shore becomes a mechanical brace.

To release the air shore, carbon dioxide gas pressure is applied to the air shore until the ram expands enough to remove the locking pin. Next the carbon dioxide pressure is reduced until the shore is free and can be removed along with the sheeting or timbers used to shore the trench.

6.254 Solid Sheeting

Occasionally excavation is necessary in materials that will not stand vertical and, because of the location, it is not practical to slope the trench. Under these circumstances you must use a solid sheeting method (Fig. 6.21). Timbers used in this method must be fully dimensional rough cut timbers. Minimum sizes are 2 x 8 inch rough timbers for trenches up to 8 feet deep and 3 x 8 inch rough timber for trenches over 8 feet deep. Metal plates can be used as solid sheeting if properly engineered. See Table 6.2, page 6-15, for additional details and requirements applying to "running" conditions.

The horizontal shoring members are generally referred to as "stringers" or "walers". When purchasing shoring material, buy the square 6 x 6 rough timber (Fig. 6.22), or the 8 x 8 rough timber because finished dimensional timber is smaller and not as strong. Either hydraulic or air shores or screw jacks can be used as cross braces.

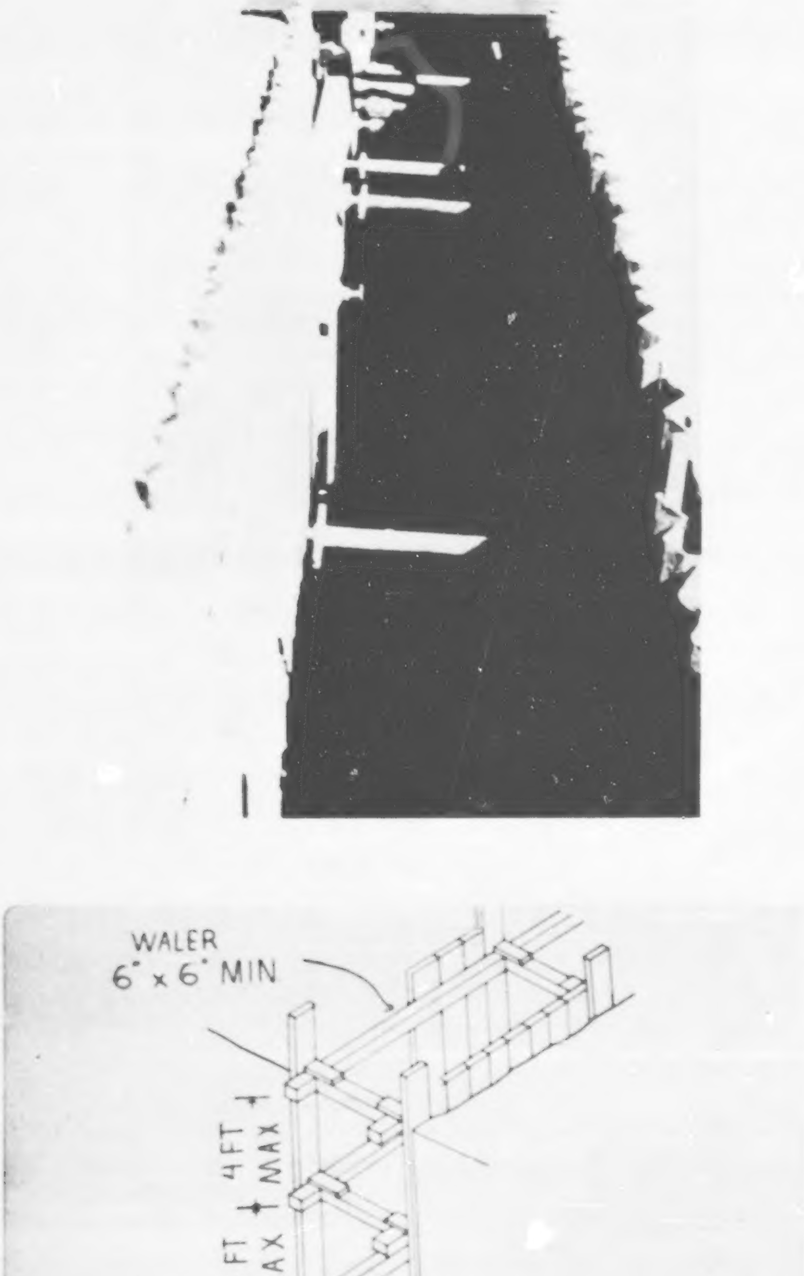
WALER
6" x 6" MIN
4 FT MAX
4 FT MAX

Fig. 6.21. Solid sheeting

STRINGER MATERIALS SHOULD BE IN THE SQUARE

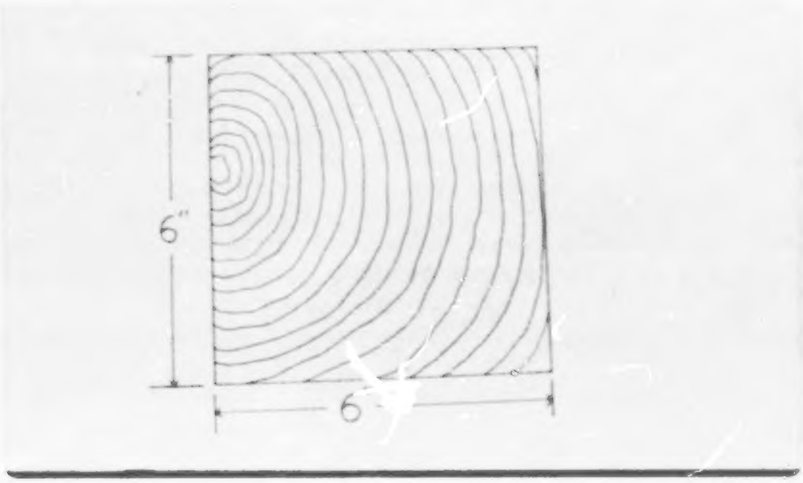

Fig. 6.22. Square 6 x 6 rough.

The same rule applies on placing the cross braces as in hard compacted materials, maximum allowable distance between cross braces is four feet. In material that requires solid sheets, the sheeting should be driven into the excavation bottom one foot or more and kept below the bottom of excavation as it goes down. All timbers used must be free from splits, large knots or loose knots. In some areas suitable timbers are extremely difficult to find. For this reason, metal sheeting may be better. Whether to rent or purchase shoring depends on expected needs and economics.

6.255 Cylinder Shoring

Cylinder shoring can be made from 1/4-inch or 5/16-inch thick steel plates that are four feet wide. These sheets are rolled into a cylinder with a four-foot inside diameter and four feet in height (Fig. 6.23). The top and bottom of each cylinder is reinforced with a welded angle iron rolled to fit the cylinders. Each cylinder section weighs either 550 (1/4-inch plate) or 675 (5/16-inch plate) pounds. This weight usually limits the use of cylinder shoring to street locations or areas where cranes or hydro lifts can be used to position the cylinders. Cylinders four feet high and four feet in diameter are easy to transport and handle, but are confining on large jobs. Larger cylinders can be made and used to rebuild or construct a new manhole.

One end of each section of a cylinder is provided with three male alignment pins approximately two inches in diameter and spaced at one-third intervals around the bottom circumference of the cylinder. The top or opposite end of the cylinders has three holes to accept the male locking pins. As the cylinder sections are stacked on top of each other, the locking pins prevent rotation or slipping of the sections. The pins thus maintain vertical alignment and structural safety at the section connections. Two hooks are installed inside the cylinders to make moving the cylinders easier.

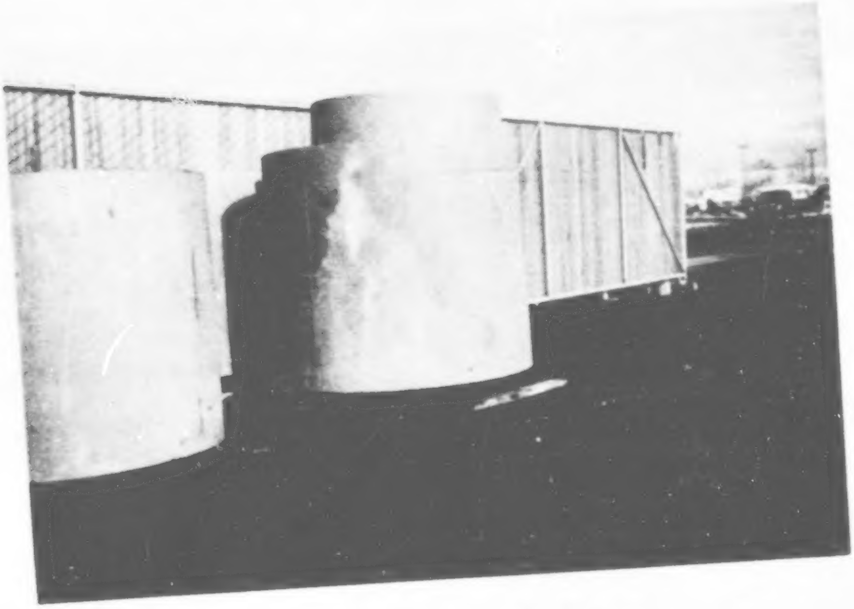

Fig. 6.23. Cylinder shoring

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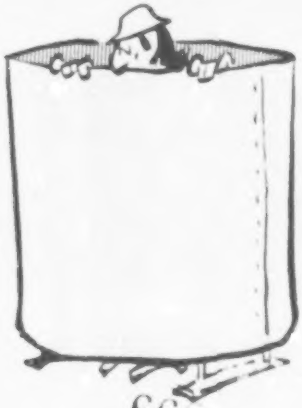
The excavation is usually started and dug as deep as practical within the safety limitations. The bottom of the hole is made as level as possible and the first cylinder is set in the hole. From here on down, it is all hand excavation. A worker and a ladder are put into the cylinder (Fig. 6.24) and a bucket and rope are used to move the spoil to the top of the ground. The cylinder is kept level as it goes down. When the proper depth is reached, another cylinder is set on the first one. This process is repeated until the excavation is completed.

Some agencies use square boxes instead of cylinders for shoring under these conditions. Another way to remove excavated soil from the inside of a cylinder or a box is to use a vacuum device like a Vac-All. Workers inside the cylinder loosen soil and guide it into the suction tube. This procedure works very well with dry soils and some wet soils. Problems develop when attempting to vacuum wet clays and any wet soil during freezing conditions because of freezing in the tube.

To reverse the procedure, backfill is dumped into the cylinders until about two feet of the bottom cylinder is filled and compacted. A chain is connected to the inside hooks of the bottom cylinder and all the cylinders are lifted up about two feet. Continue to add backfill in two foot layers, compact, and raise cylinder until bottom is at level of fill each time. Remove the top cylinder when the entire cylinder is raised to the level of the ground. Repeat this procedure of dumping fill into the remaining cylinders in two foot layers until all cylinders are raised to the ground level and the excavation is filled to grade.

The cylinder method is time consuming, but requires less time than use of sheeting, uprights, stringers and cross bracing. A limitation is that only the inside diameter of the cylinder is the working area. This approach has been used to make a new connection or repair a small portion of a main line in areas where this method was the best technique. If the working area is small and only a small portion of the main line needs to be exposed, cylinders can be very practical.



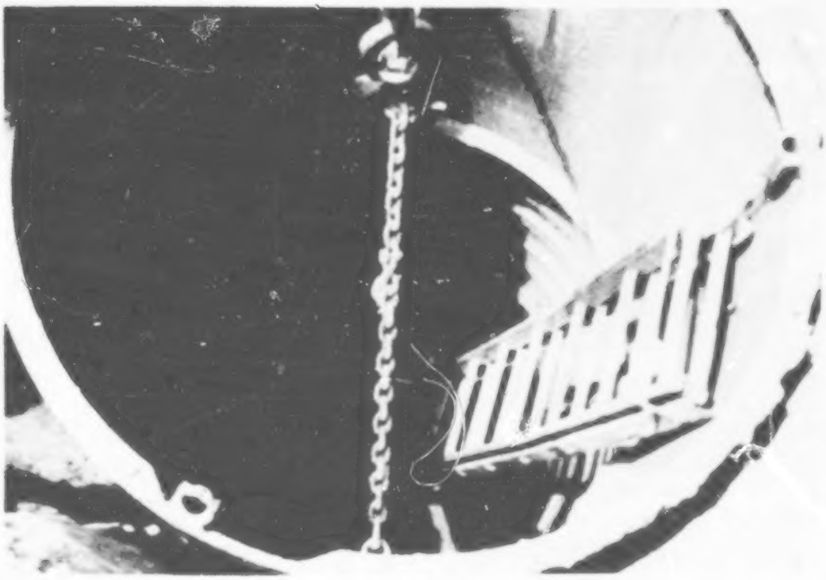


Fig. 6.24. Ladder inside cylinder.

A vertical bore slightly larger than the cylinders can be made if the soil is stable enough to hold until the cylinders can be placed in the hole. This procedure saves the time required for hand excavation and is much faster. Excavations as deep as 30 feet have been completed very successfully using this method.

6.256 Shield Shoring

Shield shoring (Fig. 6.25) is used during excavation and installation of various types of sewers in areas and soil conditions that present a combination of problems. Shield shoring consists of a rectangular box that must be opened on the top and bottom and usually the ends are open too. Size of shield depends on the size of sewer line being installed and the necessary space needed to install the pipe. Shields can vary in width from 30 inches to 10 feet and in length from 20 to 30 feet.

The City of Tacoma, Washington, has developed a shoring crib that was fabricated in their shop and can be installed in an excavation in less than 30 minutes. The following pictures on pages 6-38 and 6-39 show how the crib is installed.

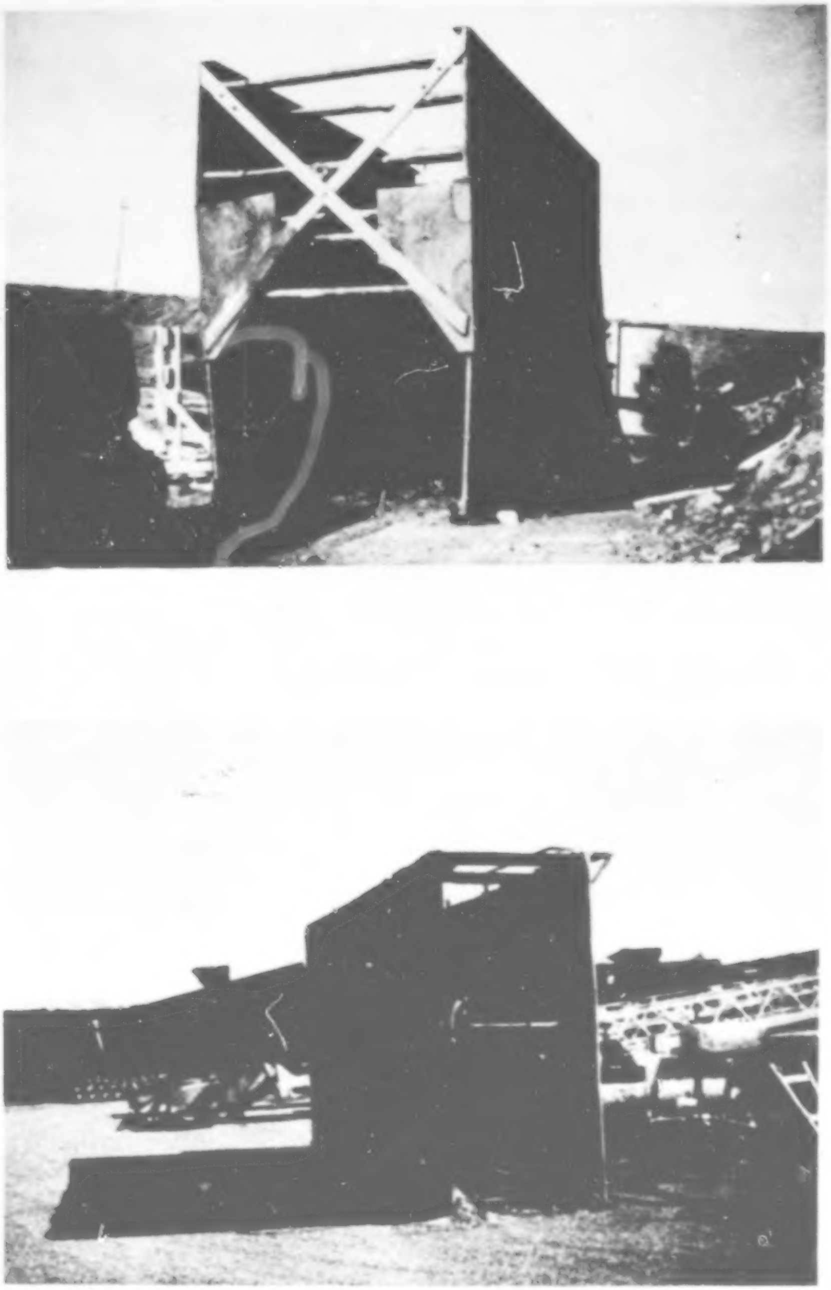
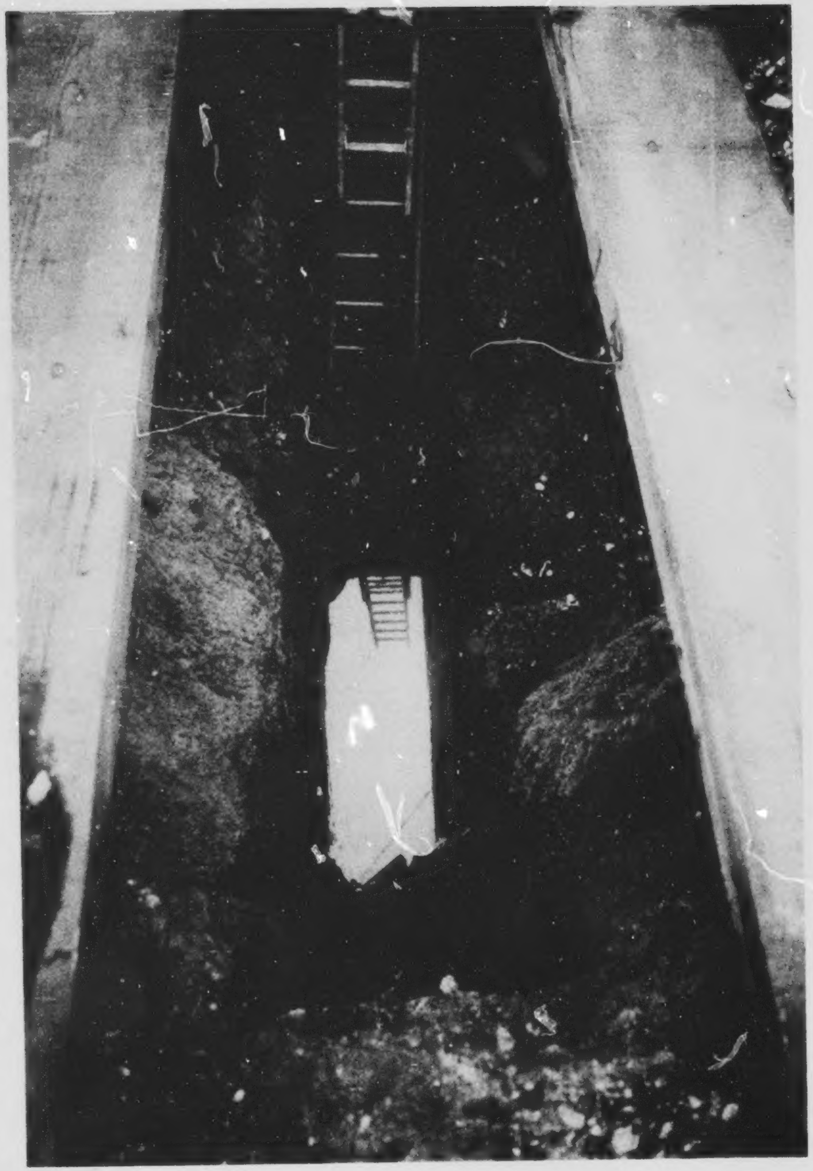
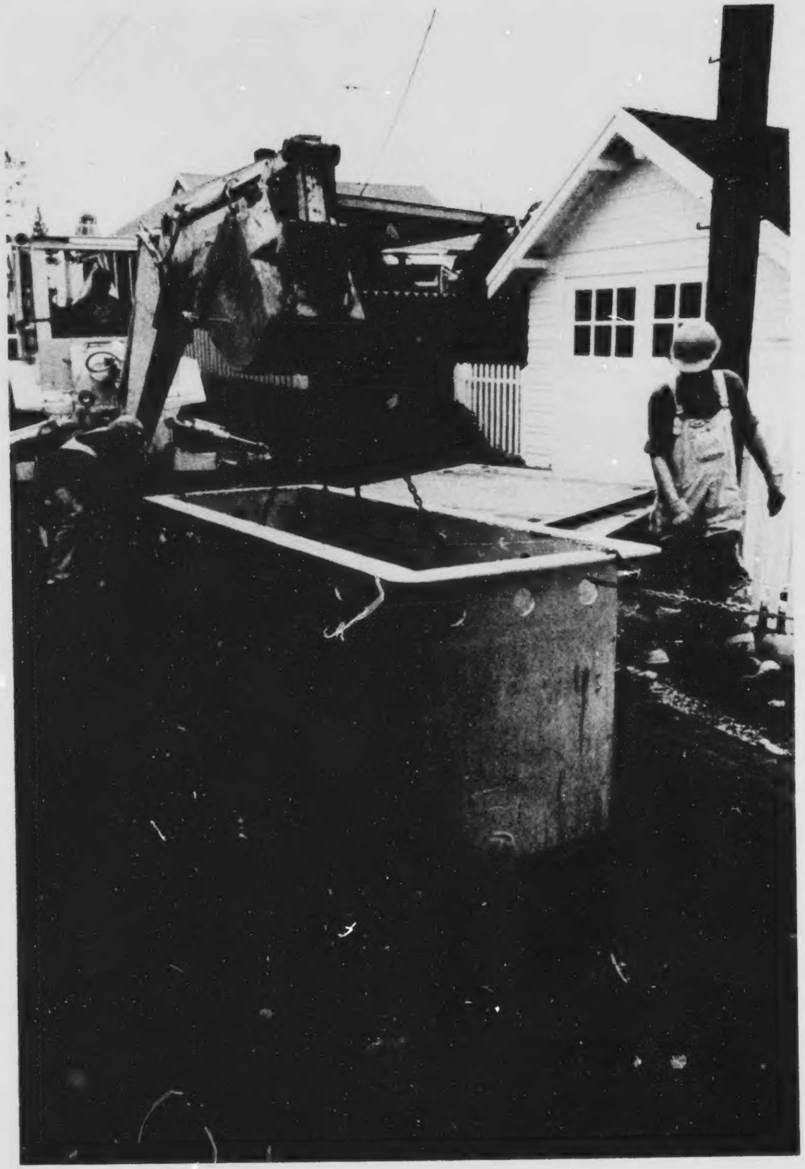


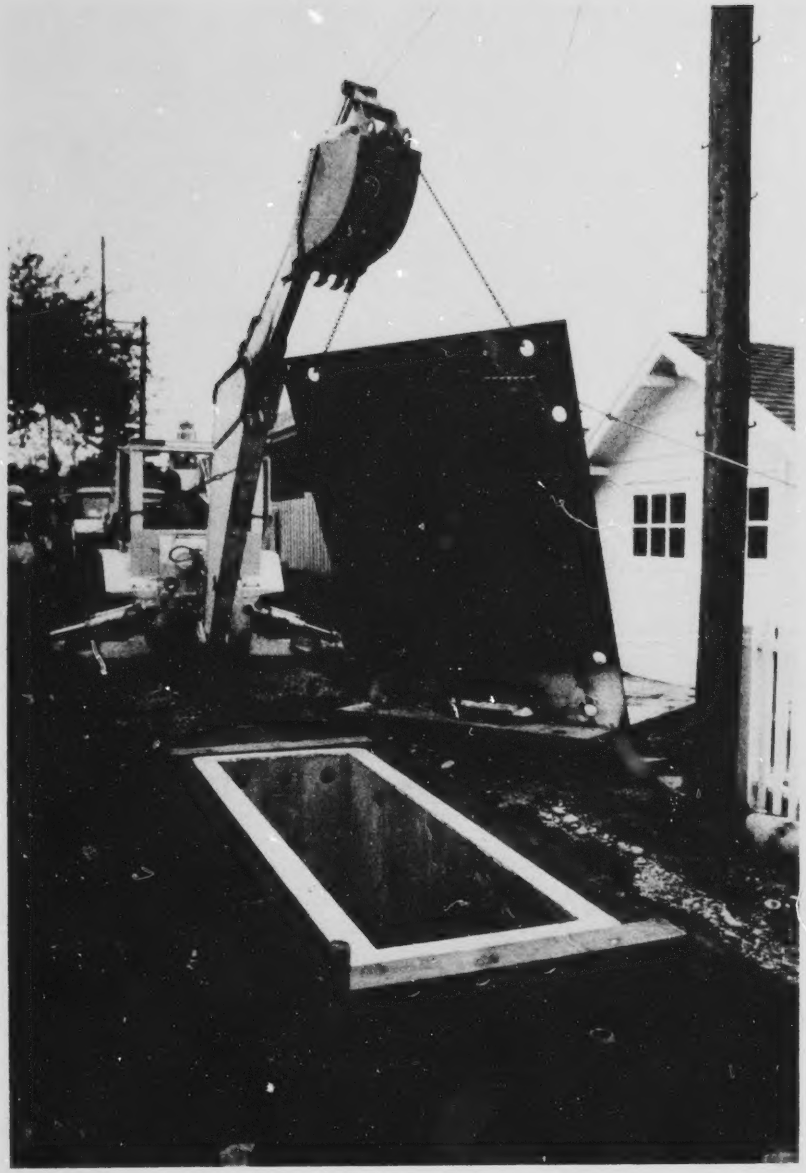
Fig. 6.25. Shield shoring.



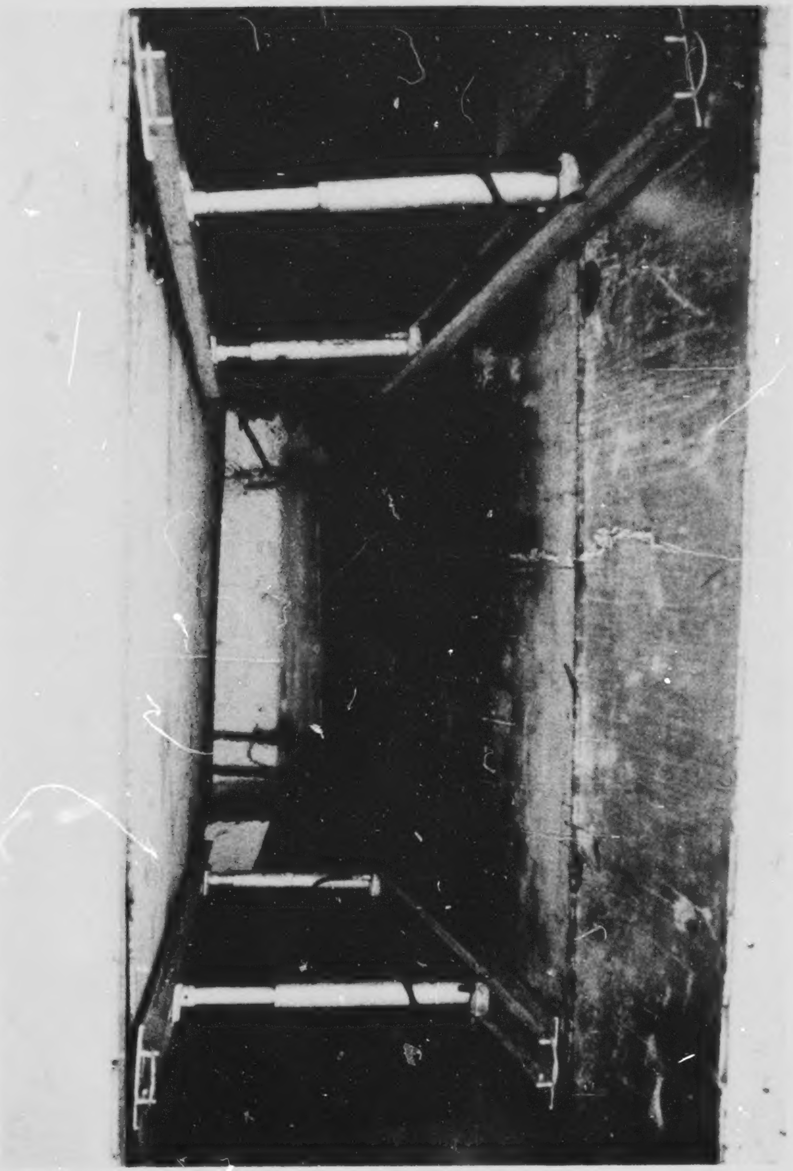
1. Dig trench.



2. Insert crib.



671 3. Install sheeting.



4. Shoring completed. 672

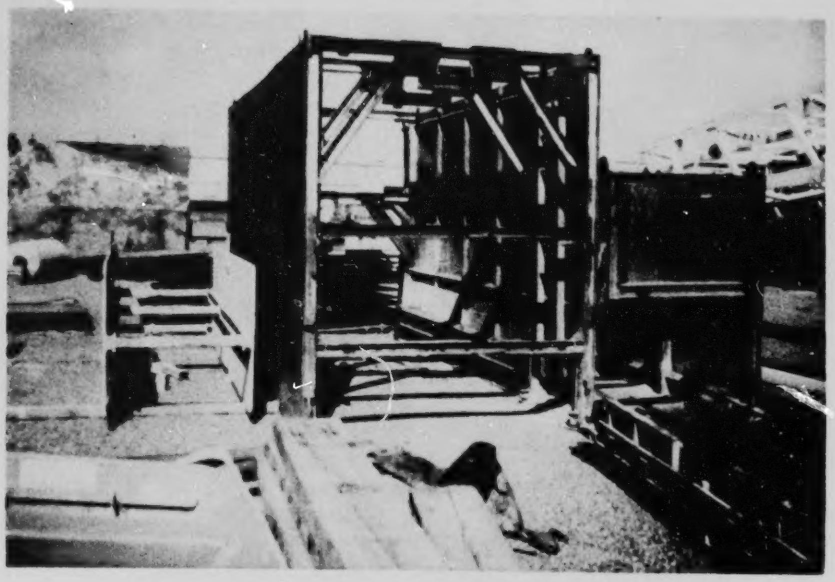


Fig. 6.25. Shield shoring.

Fig. 6.26. Trench shield being pulled by trenching machine.

If the excavation is dug with a trencher, the shield is connected to the trencher and pulled along as the trench is dug (Fig. 6.26). Pipe is laid as the trench is completed. If a backhoe or other bucket type equipment is used to excavate the trench, the shield is stationary until a portion of the trench is dug; then it is hooked onto the excavation equipment and pulled into position.

Another type shield has hydraulic rams which expand and make the rectangular box longer or contract to make it smaller. The purpose of the rams is to move the shield with its own power. In the expanded position, pipe is bedded and laid; then the rams are contracted and backfill placed behind the shield. The rams are then expanded and force the shield ahead.

The initial cost for any shield is very expensive, but often may be cheaper than solid sheeting in the long run.

6.26 Shoring Summary

This section has identified the common shores and their uses. Selection of shores depends on several factors and the job you are trying to accomplish.

Protect your workers at all cost. Attend all trench safety lectures and seminars. Contact your own safety council and see what information is available and what is required. Be sure that everyone complies with all regulations. All trenches and excavations are unsafe until properly shored, used and backfilled (Fig. 6.27).

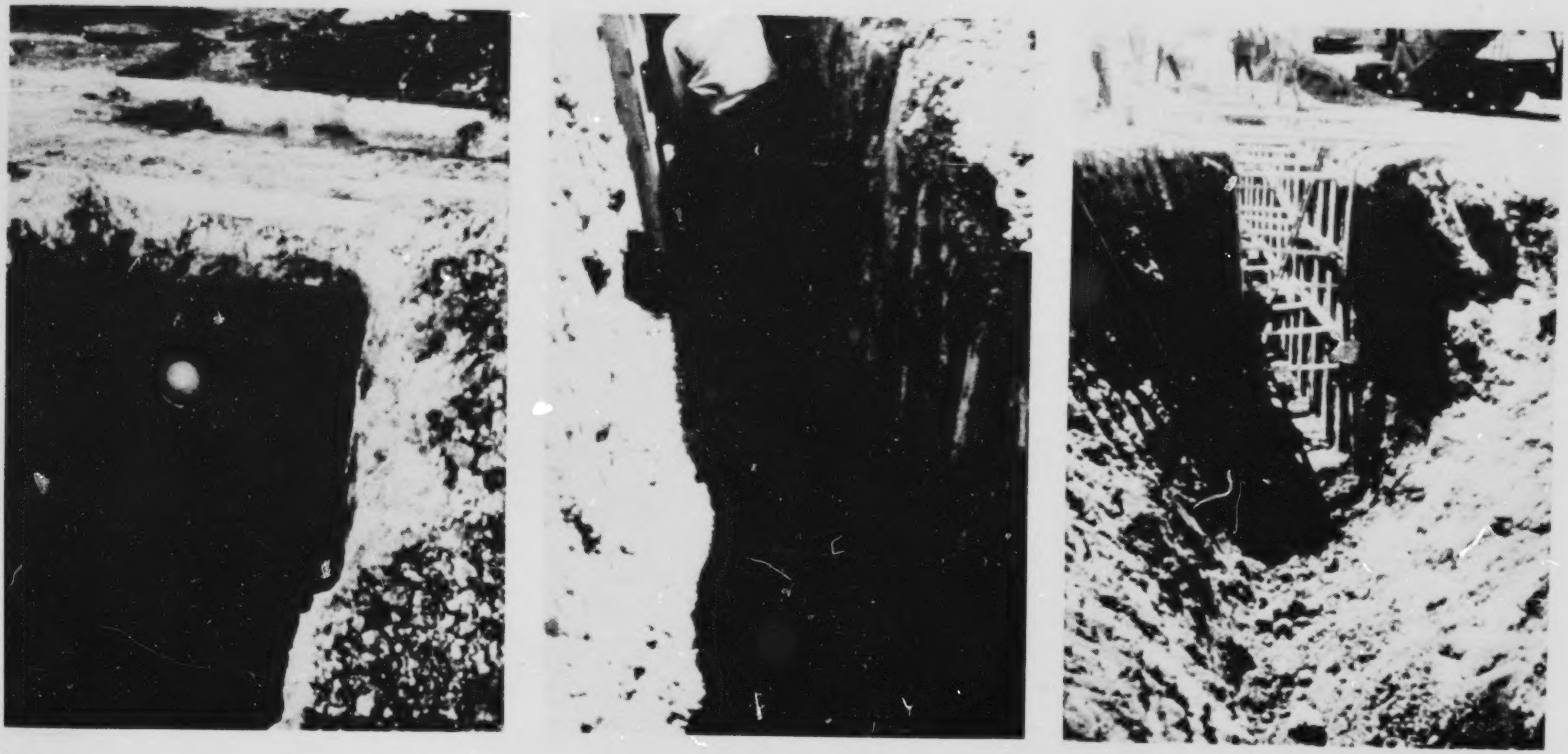


Fig. 6.27. All trenches are UNSAFE until properly shored, used and backfilled.

QUESTIONS

6.2K List the different types of common shores.

6.2L What are the main advantages of hydraulic shores?

6.2M What are the main advantages and limitations of screw jacks?

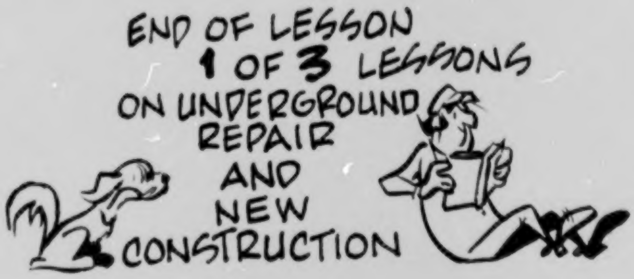
6.2N When must solid sheeting be installed?

6.2O How is material excavated in cylinder shoring?

6.2P When is cylinder shoring used?

6.2Q Under what conditions is shield shoring used?

6.2R What is the major concern during a shoring operation?


END OF LESSON
1 OF 3 LESSONS
ON UNDERGROUND
REPAIR
AND
NEW
CONSTRUCTION

DISCUSSION AND REVIEW QUESTIONS

Chapter 6. Underground Repair and New Construction

(Lesson 1 of 3 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. What safety items must be considered when excavation is required to repair a sewer located in a street?
2. Why might a sewer line have to be dug up?
3. Why should other utility companies be notified before any excavation?
4. How can workers in trenches be protected from cave-ins?
5. How can you determine the shoring requirements in your area?
6. What are the different types of shoring and the advantages and limitations of each type?

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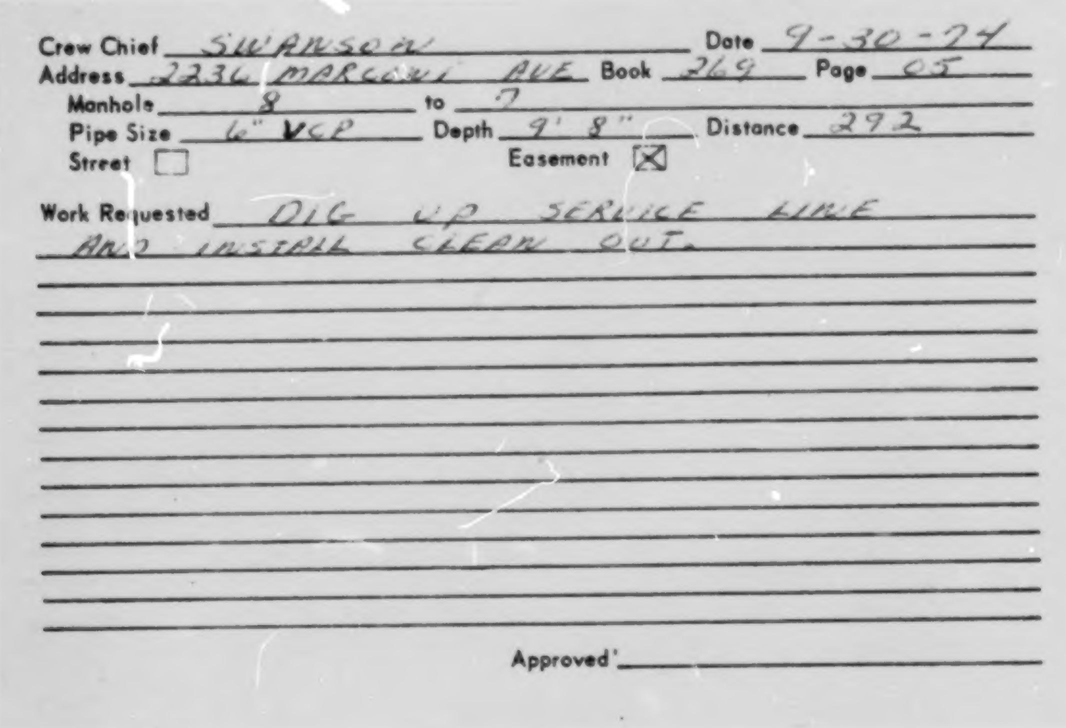
CHAPTER 6. UNDERGROUND REPAIR AND NEW CONSTRUCTION

(Lesson 2 of 3 Lessons)

6.3 REPAIR OF SERVICE LINES

Building or house service lines must be repaired when the lines develop stoppages or leaks. Repair crews are notified of a repair job when they receive a work order form from their supervisor. Repair assignments must be made in writing in order to maintain records and provide a history of who made what repairs when, where and why.

This section describes the steps to follow in order to respond to a work order request (Fig. 6.28) to install a cleanout. A cleanout was required in this example because one was not installed when the sewer was built and the cleanout is needed to help when clearing a a reoccurring root problem.



Crew Chief SWANSON **Date** 9-30-74
Address 2236 MARCONI AVE **Book** 269 **Page** 05
Manhole 8 **to** 7
Pipe Size 6" VCP **Depth** 9' 8" **Distance** 292
Street ☐ **Easement** ☒

Work Requested DIG UP SERVICE LINE
AND INSTALL CLEAN OUT.

Approved ________________

Fig. 6.28. Work order request to install a cleanout.

6.31 Preliminary Investigation

Upon receipt of a work order request, existing records are examined to determine if the problem has occurred in the past. Existing records may indicate the types of problems and soil conditions the repair crew could encounter in the field.

A foreman makes a preliminary field investigation and alerts the property owner that a crew will be digging in the yard to repair the problem sewer. A brief explanation of the job to be done is good public relations, such as how much digging will be done and where in order to install a cleanout and/or replace a faulty section of sewer. The foreman also looks for potential problems so the foreman can alert the crew leader (Maintenance Man II) of any unusual problems that may exist. Helpful information includes large shrubs that have to be removed or flowers and shrubs that have to be transplanted. Utility companies must be contacted and requested to locate their utilities in the vicinity of any excavation.

After the preliminary investigation, the work order request is given to a repair crew.

6.32 Job Assignment to Repair Crew

After receiving the work order request from the foreman, the crew leader and foreman discuss the job. How to meet safety requirements and what materials are needed are reviewed.

The crew leader has the responsibility to inspect the personal safety equipment of the crew. Inspection must include examination of steel toed boots, hard hats, gloves and safety glasses (Fig. 6.29).

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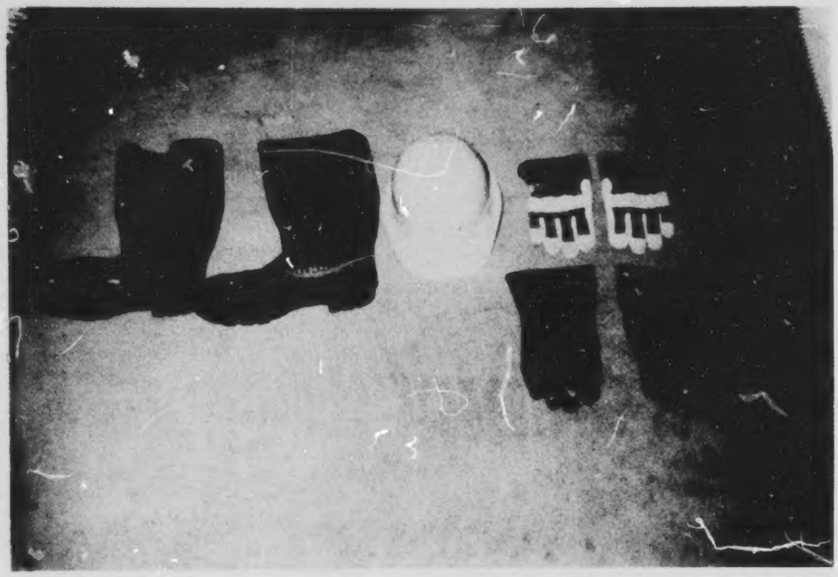


Fig. 6.29. Personal safety equipment.

6.33 Equipment, Materials and Tools

Proper tools, equipment and materials to do the job must be on the repair crew's truck before they drive to the job site.

Material usually required for sewer repair and cleanout installation include sections of 4-inch pipe, 4-inch wyes with main barrel ranging in length from 16 to 22 inches, 1/8 bends or 45^o elbows, 4-inch couplings, 4-inch bushings, and plastic plugs (Fig. 6.30).

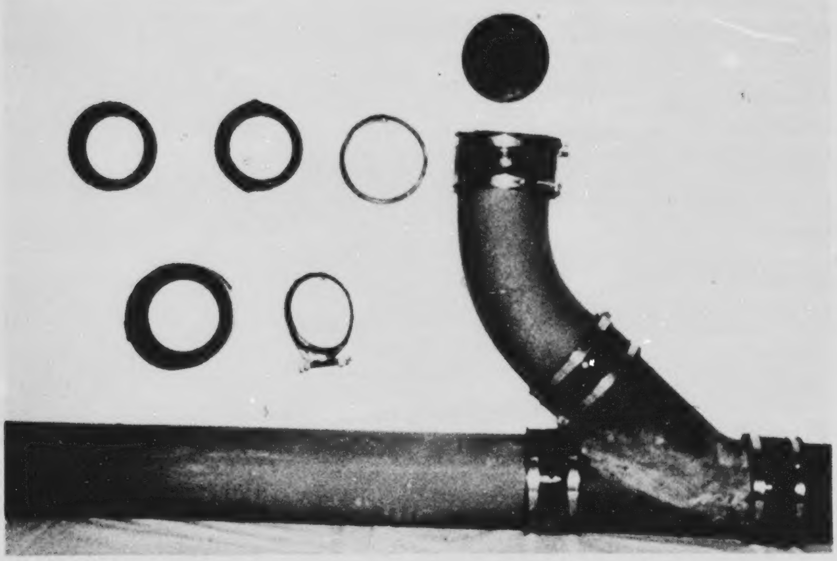
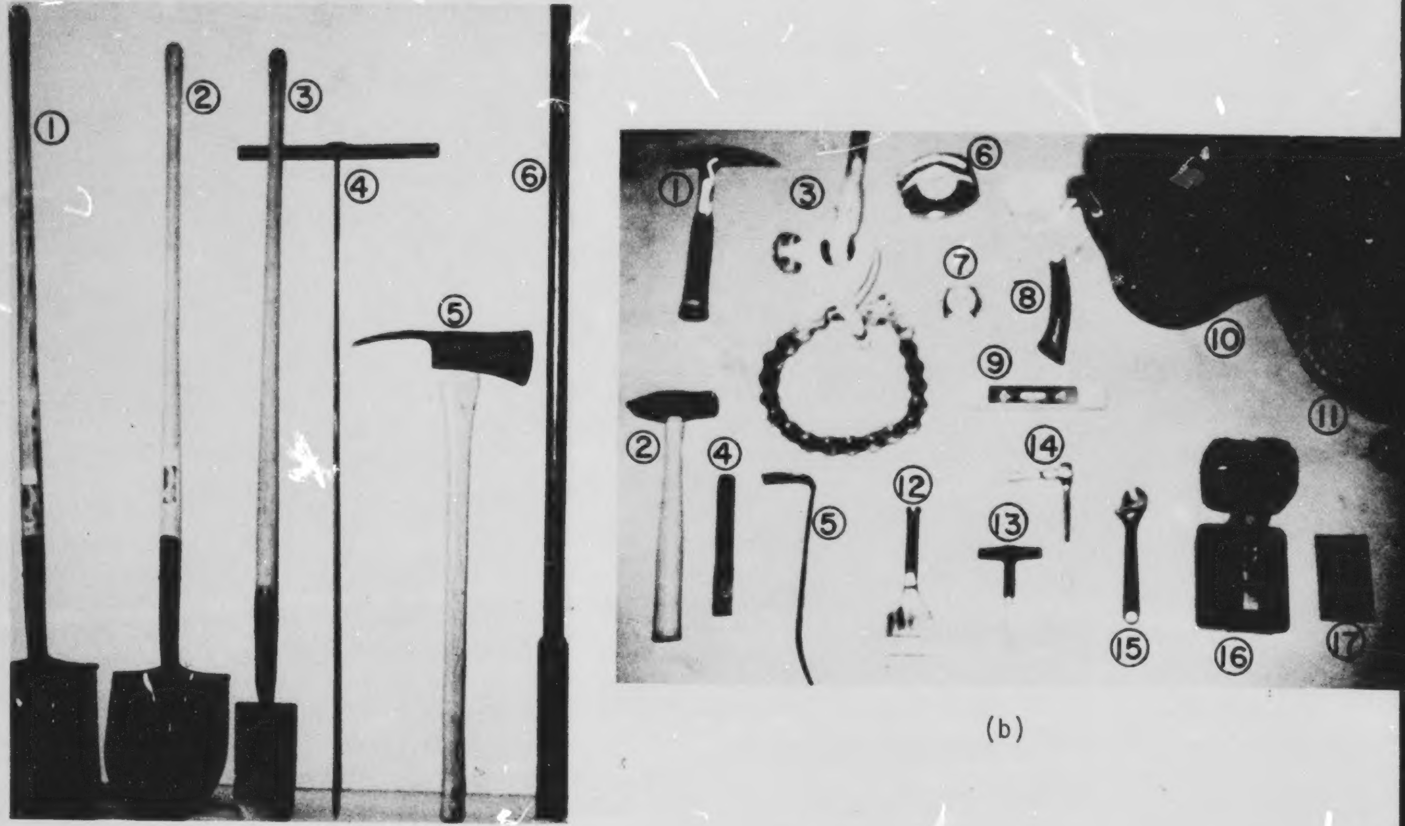


Fig. 6.30. Material for repairs.

Tools required by repair crews include round point, square point and narrow cut down shovels (Fig. 6.31). These shovels are used for removing sod and exposing pipe for repair or clean out installation. The narrow shovel is usually made by cutting down the width of a round point shovel that has had the handle broken; however, they may be purchased new. A narrow shovel is used to remove dirt between the pipe and existing ditch line.



(b)

(a)

Fig. 6.31. Tools used for repairs.

(a) 1. Square shovel
2. Round point shovel
3. Narrow shovel
4. Probe
5. Mattock
6. Digging bar

(b) 1. Miner's pick
2. 2 lb. hammer
3. Rachet cutters
4. Cold chisel
5. Wonder bar
6. 50 ft tape
7. 10 ft tape
8. Hatchet
9. Level
10. Bucket
11. Rope
12. Electrician's chisel
13. Torque wrench
14. Rachet and socket
15. Crescent wrench
16. Battery lantern
17. Mirror

Other hand tools may include a miner's pick for cleaning under pipe or for hard dirt near pipes, pipe cutters to cut and remove pipe that is broken or must be removed for the installation of a new fitting, six-foot digging bar, tape measure, rope and a bucket for lowering and removing small hand tools from the excavation, two-pound drill hammer, cold chisel, wonder bar, eletrician's chisel, 3/8-inch drive rachet and 5/16-inch socket, battery powered lantern and a small hand mirror for looking upstream and downstream once the line is opened to examine for debris left during removal of damaged section. A wide ground cover canvas is helpful to protect lawns. Hydraulic shores, screw jacks and timbers to shore excavations are needed (see Figures 6.12 through 6.19). See Chapter 9, Safety for the Collection System Worker, for safety equipment, including a first aid kit.

6.34 Arrival at Job Site

When traveling to and from the job site, seat belts must be worn. When arriving at the job site, verify that the address and map location are correct. As soon as the truck is parked, traffic cones should be placed on the traffic side of the truck. One cone belongs in front of the truck and the others at the rear of the truck. These cones alert traffic and make drivers aware of the parked repair truck (Fig. 6.32). See Chapter 4, Section 4.11, Traffic Safety, and Chapter 9, Section 9.32, Traffic Control.

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4.11 ON PAGE 4-2

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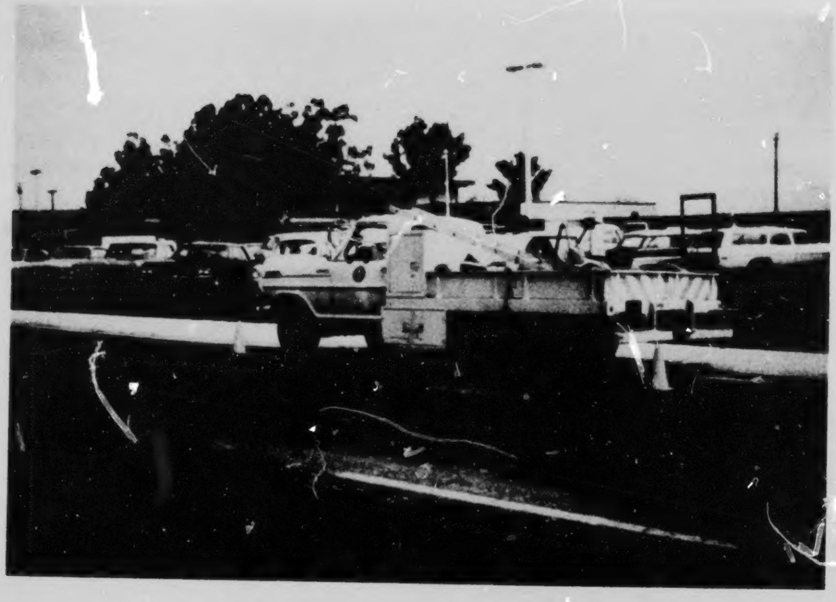

Fig. 6.32. Placing traffic cones around truck.

A common practice and a good requirement is to wear a hard hat whenever out of the truck at a job site. Hard hats protect your head from crank-out windows on the sides of homes and buildings and from clothes lines and low clothes line poles.

Notify the property owner that you must enter the property to repair the sewer and install a cleanout on the service line to eliminate the sewer problem. Inspect the area with the property owner. Identify any plants or shrubs that have to be transplanted or replaced.

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QUESTIONS

6.3A Why should repair assignments be made in writing?

6.3B What items should be reviewed during the preliminary investigation of a work order request?

6.3C What should be inspected before a crew drives to a repair job?

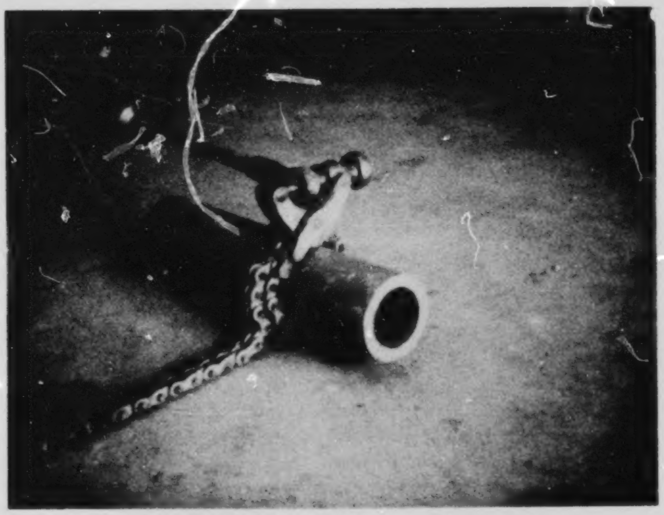
6.3D What should be done upon arrival at the job site?

6.35 Starting Repair (Excavation)

Locate the service line to be repaired. After inspecting the repair area, materials and tools can be brought into the yard. A wide ground cover canvas is placed over lawn grass near the edge of repair area. The canvas helps keep grass from being damaged or destroyed during repair and helps speed backfilling of ditch when job is completed.

Use a square point or a sod shovel to cut an area approximately two feet wide and eight feet long. This 2 x 8-foot section should be cut into smaller sections for ease of handling. Sod sections are placed away from where dirt is going to be stacked. This is to make shoveling dirt into the trench easier. Use the round point shovel to start removing dirt. After about 12 inches of dirt have been removed, a rod or probe is used to locate any possible water or gas lines in the area being excavated that may have been overlooked or forgotten by the utility agencies. In some areas a common practice is to install the water service lines and sewer service lines in the same ditch. Proceed with caution to dig the ditch down to the sewer service line. If a water line is located, caution should be used not to hit or strike the water service line. If utilities are encountered in the excavation of a trench, support the utilities so they won't crack or break. A brace can be placed across the trench and cables extended from the brace to the utilities to provide support. If the sewer service line is deeper than five feet or if hazardous soil conditions are encountered, install adequate shoring (Section 6.2).

Clean the area alongside and under the section of sewer line to be removed to give access to rachet-type chain cutters (Fig. 6.33).



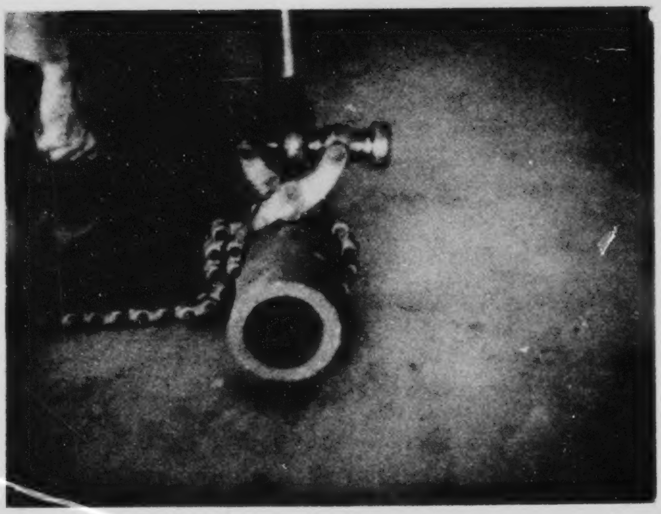


Fig. 6.33. Rachet-type chain cutters.

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6.36 Cutting Pipe

Rachet cutters are placed on the pipe and end of chain is fed under pipe and attached to jaws of cutters. Be sure that the chain is properly attached. Rachet cutters are marked cut and open. To cut pipe, the side marked CUT is aligned with arrow. Apply a downward pressure on handle until pipe is cut. If pipe does not cut during first stroke, lift up on handle until it is at about a 90 degree angle and push downward a second time. Make several cuts (usually three) so pipe section can be removed without damaging remainder of pipe. After the pipe is cut, measure the distance to the next cut, such as for a wye. Install the pipe cutter at the proper location and make the next cut. After all cuts are completed, remove pipe cutter from trench.

Remove section of pipe that has been cut. Be careful not to cut or scratch yourself on the sharp pipe edges.

Inspect service line for any problems using a lantern and mirror. Remove any roots or other obstructions from the line and repair any breaks observed in the line.

6.37 Install Cleanout

If service line is found to be satisfactory or after repair, install a wye. A wye is installed to give access to a portion of the service line leading to the main line[5] (Fig. 6.34).

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[5] Main line. Branch or lateral sewers that collect wastewater from building sewers and service lines.

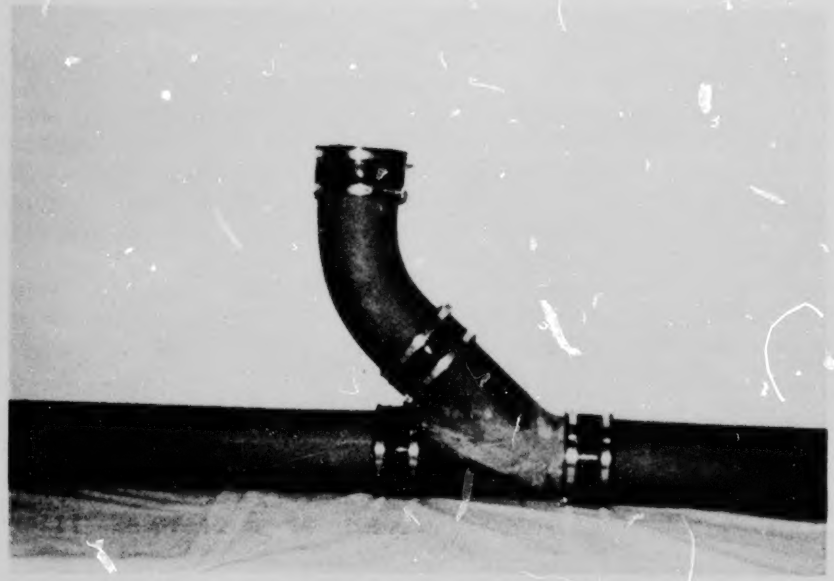


Fig. 6.34. Wye and cleanout.

Place gravel, sand or crushed rock in bottom of trench for bedding of wye. After wye is in place, install a 1/8 bend or 45° elbow in upper leg of wye if needed. A section of 4-inch clay pipe is then installed into the 45-degree bend and brought up to ground level (grade). A 4-inch plug is inserted on the end of the pipe at ground level. Tighen all couplings or seal joints. Make a quick inspection of ditch for tools before preparing bedding and backfilling trench.

6.38 Bedding, Backfilling and Compaction

Proper bedding is very important. Be sure bedding is of suitable soil or material to provide a firm base. Tamp the bedding so it won't settle after the job is completed. A smooth bedding surface is essential to prevent the cleanout or pipes from shifting.

Start to backfill the ditch. A square point shovel is often used for backfilling. A water hose is required for jetting. The hose is placed near the bottom of the ditch. As dirt is being backfilled into ditch, the hose is pulled up to allow all backfilled soil to be soaked. This process provides compaction of soil in the ditch and prevents extreme settling from occurring at a later date.

Care must be taken to prevent large chunks of dirt or rocks from striking the sewer service line. Pipe breakage can occur or a coupling can be knocked off, causing a leak to develop.

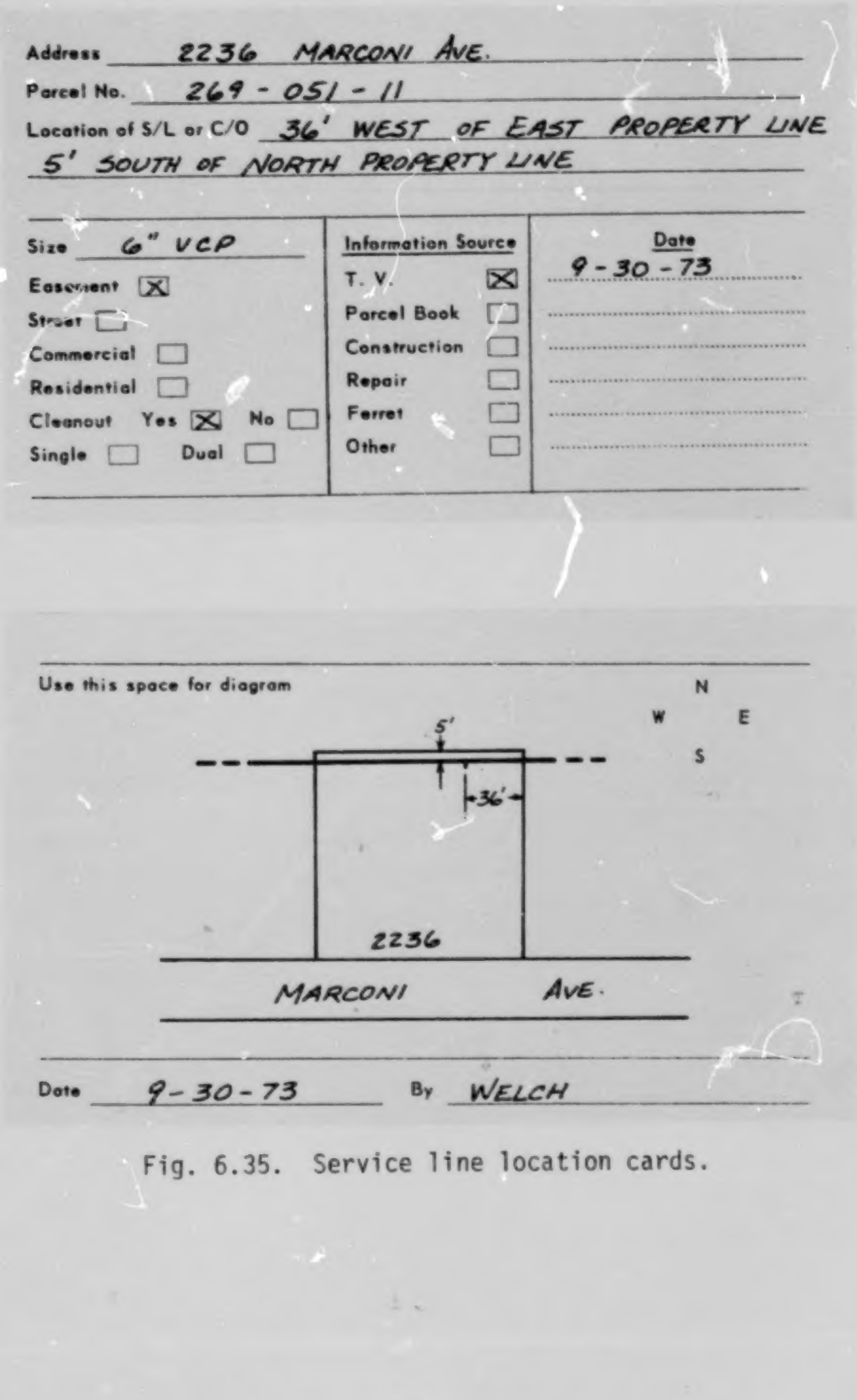
After all dirt has been replaced into the ditch and the sod and bushes put back in place, a visual inspection of the repair area should be made to be sure the work area has been returned as close to original conditions as possible. Be sure all tools have been accounted for, cleaned and loaded on truck. Notify the resident of the home when the job is completed.

6.39 Complete Service Line Location Card

Measure the distances of the cleanout from both property lines. These measurements and a sketch of the area are for future reference to help locate the cleanout (Fig. 6.35). Record observations of conditions and problems encountered during any repairs and installation of cleanout.

Before entering truck, carefully walk around truck looking for children, toys and other items and then pick up traffic cones. Also look inside the trucks and equipment for children.

Upon returning to maintenance yard, discuss with your foreman any future problems that you think might develop. Potential problems include plants destroyed, trees hit, fence posts weakened, or a need for more dirt after settling. This information gives the foreman a chance to discuss these problems with the property owner and usually can avert some bad public relations at a later time.



Address 2236 MARCONI AVE.

Parcel No. 269 - 051 - 11

Location of S/L or C/O 36' WEST OF EAST PROPERTY LINE

5' SOUTH OF NORTH PROPERTY LINE

Size 6" VCP

Easement ☒

Street ☐

Commercial ☐

Residential ☐

Cleanout Yes ☒ No ☐

Single ☐ Dual ☐

Information Source

T. V. ☒

Parcel Book ☐

Construction ☐

Repair ☐

Ferret ☐

Other ☐

Date

9-30-73

Use this space for diagram

N
W
E
S
5'
36'
2236
MARCONI AVE.

Date 9-30-73 **By** WELCH

Fig. 6.35. Service line location cards.

QUESTIONS

6.3E When excavating to repair a sewer line, why should the soil removed from the excavation be placed on a canvas?

6.3F What cautions should be exercised when excavating to repair a sewer line?

6.3G What is done after a section of pipe is cut and before a cleanout is installed?

6.3H What kind of bedding material is used for the wye of a cleanout?

6.3I What should be done before a trench is backfilled?

6.3J What is the purpose of the service line location card?

6.3K What should the crew leader do upon returning to the yard?

6.4 MAIN LINE REPAIR

Main line repairs are required when a sewer line repeatedly shows partial or complete stoppage of flow. Partial stoppages may require only cleaning. Broken and collapsed pipes and offset joints are examples of sewers needing repairs. To describe the procedures for repairing a main line, let's replace a section of 8-inch sewer in the street.

6.41 Preliminary Field Investigation

Before starting repair of a main line, the foreman makes a preliminary field investigation to identify potential problems, obtains necessary permits and plans the repair job. A work order prepared by the TV inspection crew indicates that a section of 8-inch sewer needs replacement. Paint is used to mark the repair area on the street surface. All utility companies are contacted and requested to identify the location of their utilities in the area of the repair site. Representatives of the utility companies involved (water, natural gas, fuel pipe lines, electrical power and telephone) meet with the foreman at the site and mark the location and depth of their system. Contact local traffic control agency if permits are needed to reroute traffic or any other problems handling traffic are anticipated.

6.42 Crew and Assignment

This main line repair job requires at least a three-worker crew. The crew chief is a collection system repairman (Maintenance Man II) and a qualified backhoe operator (Construction Equipment Operator). The crew chief is helped by two assistant collection system repairmen (Maintenance Man I). In some states the driver of a vehicle that transports equipment to a job site may have to obtain a special driver's license.

A collection system supervisor (foreman) reviews the work order and prepares a time sheet. Also the foreman prepares a sketch of the job site showing the location of all utilities and other important information. This preliminary information, the proper procedures and safety precautions, and the necessary equipment, tools and materials are discussed by the foreman with the crew chief.

6.43 Materials, Equipment and Tools

Materials required for this particular job include sections of 8-inch vitrified clay pipe, 8-inch band couplings and sufficient crushed rock to prepare a bed for the new section of 8-inch pipe to be replaced.

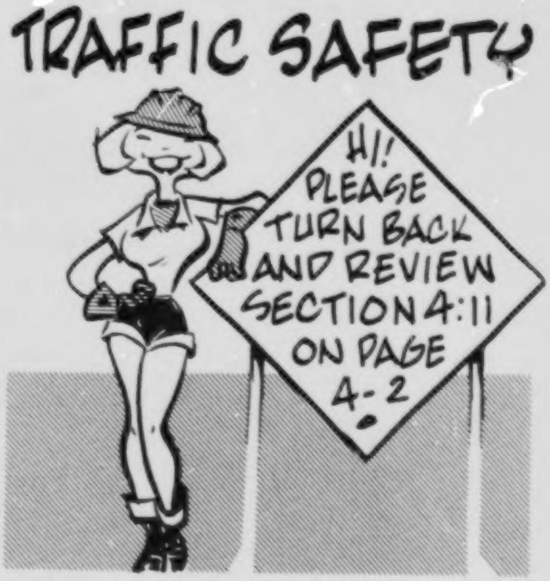
Equipment required for this job includes a backhoe, dump truck, tilt bed trailer, 1-1/2 ton flatbed truck equipped with an air compressor to operate a pavement breaker and a pneumatic tamper, and a water truck with a 1500-gallon capacity tank.

The dump truck pulls the trailer loaded with the backhoe. The 1-1/2 ton flatbed truck carries all pipe repair materials, air and hand tools and safety equipment (shoring, personal and traffic control). The water truck has a portable 2-inch pump mounted on the tank and carries all the hoses and pipe needed for jetting purposes during backfill. A 24-foot aluminum extension ladder and extra shoring jacks and sheeting for bigger and deeper jobs also are carried by the water truck. All portable equipment (such as equipment on trailers) pulled to a job site must use a pintle hook and have a safety cable placed around the pintle hook and portable equipment.

Before the crew leaves the yard, they inspect all equipment (including safety) and determine that all the necessary equipment, tools and materials needed to do the job are loaded on the trucks. Hard hats should be worn by the crew at all times. See Chapter 9, Safety for the Collection System Worker, for safety equipment, including first aid kit.

6.44 Arrival at Job Site

When the crew arrives at job site, they locate the marked repair area and park trucks in safe and convenient locations. The flatbed truck should be parked close to the repair area so it can be reached with air hoses and pavement breaker. Prepare traffic control using high flags and traffic cones (see Chapter 4, Section 4.11, Traffic Safety and Chapter 9, Section 9.32, Traffic Control) to protect equipment, work area and workers. Contact the homeowner and owners of parked vehicles that are in the work site area or in driveways that will be blocked during repair of the main line. Explain to these people that a major repair on the sewer line must be done now and request their cooperation. Assist them, if neccessary, to minimize inconvenience while doing the job. If parked vehicles are a potential problem, the job site can be barricaded and marked the night before or very early in the morning.


TRAFFIC SAFETY
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QUESTIONS

6.4A What should a foreman do before a crew is assigned a main line repair job?

6.4B What information does the foreman need from other utility agencies at the job site?

6.4C What items are discussed by the foreman and crew chief before the crew starts the job?

6.4D What should the crew do before leaving the yard for the job site?

6.4E What should the crew do when arriving on the job site?

6.45 Cutting Pavement

After observing traffic flow for proper control and safety, the area of the pavement to be cut is marked off with a chalk line. The cut in the pavement should be 30 inches wide and 10 feet long for this job. Before marking and cutting, verify the repair locations by measuring the distance from the designated manhole. Also measure the distance from manhole to manhole and other important distances to verify the accuracy of the sketch.

Start the air compressor and allow it to warm up. An assistant collection system repairman (Maintenance Man I) puts on safety glasses, ear plugs, and required safety shoes. A cutting blade or other suitable tool, depending on type of pavement, is locked into the pavement breaker. The air hose is connected and the safety chains are locked in place. The safety chain is required to prevent the air hose from whipping around if the hose connection comes uncoupled from the breaker. Some hose connections are equipped with a double-spring lock and do not require a safety chain.

Cut the pavement along the chalk lines. While the pavement is being cut, the backhoe is unloaded from the trailer and lubricated. The trailer is unhooked from the dump truck and parked. Crushed rock is dumped near the repair area for later use.

Open the upstream and downstream manholes. Observe and record the amount of flow and the depth to the top of pipe. This depth indicates to the backhoe operator how deep to excavate. Also this observation can reveal if the line is plugged by causing flow to back up into the manhole.

After the black top is cut, the pavement breaker and air hose are put away and the flatbed truck is moved to make room for the dump truck and backhoe. The hoe operator examines the work order for the location of utilities and confirms their locations in the marked area.

6.46 Excavation

Start digging with the backhoe. Load directly into dump truck the black top or road surface, subbase rock, and the soil down to about two feet below the road surface. Watch for changes in soil texture or other signs that could indicate the presence of cross trenches or other underground utilities.

At this depth, determine if spoil (excavated materials) are suitable for backfill. Usually the original trench backfill material will make suitable backfill material again.

Dump truck travels to gravel plant to dispose of excavated pavement and subbase and returns with approximately three yards of 1-1/2 inch road rock. Continue digging with backhoe. Keep the spoil pile at least four feet from the edge of the trench if the trench is over five feet deep. If shallower, spoil must be at least two feet from edge of trench; however, a distance of four feet is recommended. An assistant repairman (Maintenance Man I) uses a square point shovel to keep the working area clean. Everyone must be alert. Watch the backhoe and the trench for signs of utilities and anything unusual. Continue excavating until approximately 1-1/2 feet above the sewer main line which is to be repaired. Use an extension probe to determine the exact distance to the main and the amount of material remaining over the top of the main. The backhoe operator must be careful to avoid damaging the line. If shoring is necessary, refer to Section 6.2, Shoring.

The backhoe continues to dig down to within one to four inches of the main, depending on the operator. Continue to determine the location of the main line with the probe. Do not break the main line.

If water is encountered, a sump will have to be dug. Use a trash pump to remove the water and discharge it into a manhole or catch basin. By now the dump truck has returned with the gravel and is parked out of the way.

6.47 Pipe Repair

After the shoring is installed and the trench is determined safe, place a ladder into the trench. Leave the ladder in the trench as long as a worker is in the trench.

A round point shovel is lowered on a rope to the worker in the trench to uncover the main line and locate the problem area. A narrow shovel is used to dig alongside of the pipe and to dig down below the main line when necessary.

A miner's pick and wonder bar are lowered down in a bucket to the worker in the trench. These tools are used to dig under the main line about a foot and a half each way from the broken bell section of the pipe which is to be replaced.

Remove all loose dirt from under the pipe before cutting the pipe for repairs. When the main line is cut, the flow drops into the trench, fills the hole and flows out the downstream pipe. If loose dirt is not removed, this water will mix with the loose dirt and form a sloppy mess unsuitable for bedding material.

Have a sump pump and hose standing by in case water in excavation must be pumped out. Pump to the downstream pipe or to a downstream manhole. If possible, it may be necessary to plug off flows at the upstream manhole while the pipe is being repaired. Be careful not to flood any homes, businesses, or streets whenever plugs are used.

To prepare for cutting the pipe, the repairman in the trench must be wearing safety glasses, steel toe rubber knee boots and gloves. Lower the pipe cutters into the trench to the repairman. Cut the pipe approximately one foot on each side of the break in the main line. Wrap cutters around the main and cut the pipe two or three times at both locations where the pipe is to be cut. This many cuts are necessary so the good pipe won't chip or crack when the damaged section of pipe is broken out. Use the miner's pick to break out the bad pipe. Remove the pipe and debris from the trench using a bucket and rope.

Lower a mirror and flashlight into the trench. Inspect the main line for cracks, roots, and bad taps and joints in both directions from the cut.

Measure the distance between the cut pipe ends --- for example, 25 inches. Inform the workers topside of the length needed. Cut a 24-1/2 inch long piece of pipe off a section of 8-inch diameter pipe. This leaves a 1/4-inch gap at each end of the repair section to allow the centering stop of the band couplings to fill these gaps.

Lower the bedding material in buckets and place it in the void under the pipe. Leave enough room at the cut ends to slide couplings around the existing main line.

Center two 8-inch band couplings on the ends of the new pipe section and mark the location with a pencil or anything handy for a centering reference. Lubricate and slide the couplings completely over the new pipe section so the ends are even or flush.

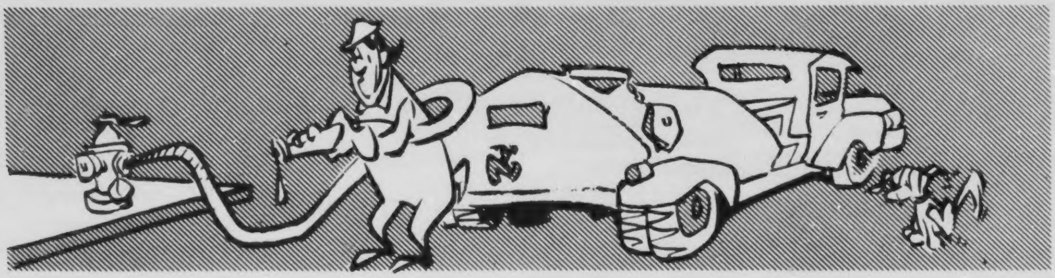
Lower the short piece of pipe and couplings into place between the main line ends. Slide the couplings over the existing main to the reference marks on the pipe as previously discussed. The coupling's center stop should drop into the 1/4-inch gap. If the band coupling does not seat, rotate the pipe section.

Tighten the stainless steel bands with a special torque speed wrench designed for the band couplings. If the wrong wrench is used, the pipe can be damaged.

6.48 Bedding, Backfilling and Compaction

(See Chapter 3, Section 3.56, Sewer Trench Backfill and Compaction)

Move bedding material into the trench and place around the main line with a shovel. Be sure alignment of the pipe is proper for a smooth,



even flow. The bedding material should be compacted until it completely covers the pipe 6 to 12 inches.

All the tools no longer needed for the job are cleaned and put away. The water truck is filled with a load of water from the nearest fire hydrant to jet the trench. Use a backhoe to ease the excavated material back into the trench.

Park the water truck close to the repair area, and a section of 1-1/2-inch pipe is connected to the hose from the pump. Turn on the water. Start the pump. Push the pipe into the loose soil while the water is running all the way to the bottom of the trench. As the water spreads out and works its way upward, observe the top of backfill soil settling. When water is seen breaking to the surface, the pipe is pulled out and moved down the ditch 3 or 4 feet and the procedure is repeated until the entire ditch is jetted. The soil should drop to about a foot below the pavement.

The dump truck is backed to the trench and dumps the road rock to fill the ditch to a level about one foot above the pavement.

Wheel roll the gravel with the backhoe. After rolling, the gravel should drop to a level about even with the pavement.

Start the air compressor to supply air for the pneumatic tamper to better compact the road rock to 1 or 1-1/2 inches below the pavement. Practice good housekeeping and clean up the area using a square point shovel and street broom.

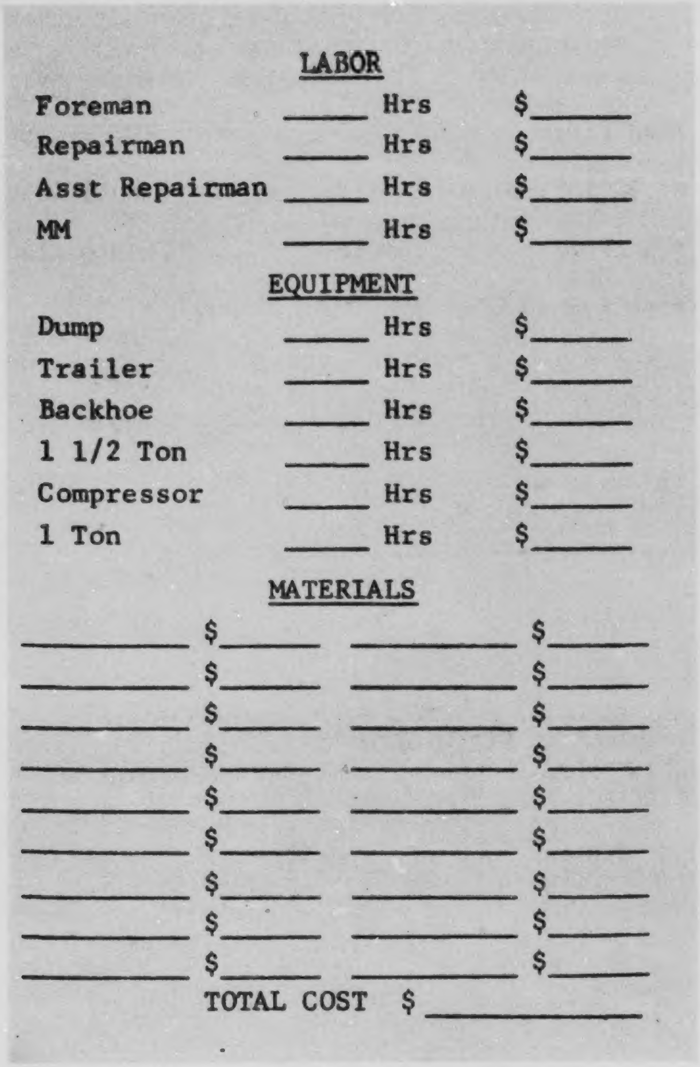
Mechnical compaction methods (tampers) are often used instead of water compaction in roads and streets. The soil used for backfill should be fairly dry before it is paved over or soft spots could develop under the pavement.

6.49 Safety

Two barricades with flashers are placed over the repaired area and left there until the paving crew can complete the patch job.

Complete the clean-up by washing down the street work area.

Connect the trailer to the dump truck and load and secure the backhoe. Time required and materials used are recorded (Fig. 6.36). The crew proceeds to the next job after all tools are cleaned and placed in their respective vehicles and the equipment is secured and ready to go.



LABOR

Foreman	_____	Hrs	$______
Repairman	_____	Hrs	$______
Asst Repairman	_____	Hrs	$______
MM	_____	Hrs	$______

EQUIPMENT

Dump	_____	Hrs	$______
Trailer	_____	Hrs	$______
Backhoe	_____	Hrs	$______
1 1/2 Ton	_____	Hrs	$______
Compressor	_____	Hrs	$______
1 Ton	_____	Hrs	$______

MATERIALS

__________ $______ __________ $______
__________ $______ __________ $______
__________ $______ __________ $______
__________ $______ __________ $______
__________ $______ __________ $______
__________ $______ __________ $______
__________ $______ __________ $______
__________ $______ __________ $______
__________ $______ __________ $______

TOTAL COST $ ____________

Fig. 6.36. Labor, equipment and materials card.

QUESTIONS

6.4F Before cutting the street, what should the crew verify?

6.4G How can the crew tell if unidentified utilities might be in the work area?

6.4H Is spoil from an excavation suitable for backfill?

6.4I How far should the spoil pile be kept from the trench?

6.4J How is the elevation of the line being repaired determined?

6.4K How close does the backhoe dig to the main line?

6.4L How is equipment and material lowered into the trench?

6.4M Why should all loose dirt be removed from under the main line?

6.4N How is the backfill compacted?

6.40 How is the job site protected until the patch crew arrives?

6.5 MANHOLE REPAIRS

Manholes must be maintained and kept in working condition just like any other structure. They must provide easy access for workers to the collection system. Frames and covers should be secure and the top at the same grade as the surrounding street or other surface. The manhole cone and barrels must be free from cracks and deterioration from corrosion. Bottom flow channels should be smooth and shelf areas should be located above the flowing wastewater, but sloped to prevent the trapping of debris during surcharge[6] conditions.

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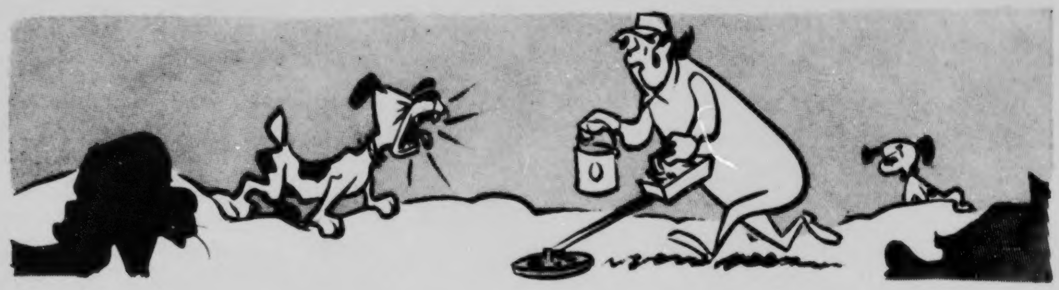
[6] Surcharge. Sewers are surcharged when the surface of the wastewater in manholes is above the top of the sewer pipe. The sewer is under pressure or a head rather than at atmospheric pressure.

Before scheduling any repair work on a manhole, carefully inspect the manhole (Section 4.3, Inspection of Manholes). Inspect for structural failures, cracks, corrosion damage, condition of bottom, shelves and channels, and elevation of manhole cover. When repairing a manhole, try to do all of the repair work at once.

6.51 Raising Manhole Frame and Cover to Grade

6.511 Detection of Missing Manholes

Missing manholes are sometimes buried or paved over when a street is repaved. Usually this problem is discovered by a preventive maintenance crew. If the manhole is buried in the easement (back or front yard, lawn or flower bed area), the preventive maintenance crew will locate and expose the manhole lid. Missing manholes may be located by the use of metal detectors, ferret locators (used with hand rods or power rodders), or television. The preventive maintenance crew will proceed with the work that has to be done in the manhole.



A work order is then written up with the information on the location of the manhole, and how many inches the frame and cover should be raised.

If the missing manhole is in the street or an alley and has been buried or paved over, the preventive maintenance crew will locate the manhole with a metal detector and mark the location with paint. If the buried manhole is not a pressing problem, the crew will again prepare a work order and turn the order over to the construction section. If the manhole is needed for immediate access, the preventive maintenance crew will contact a construction supervisor who will dispatch a crew with a compressor and jack hammer to expose and raise the manhole. The supervisor also will assist the preventive maintenance crew if needed.

6.512 Site Preparation

Once the location of the manhole to be raised is established, the following action is taken to raise a manhole in an easement:

1. Take care to remove the lawn sod, shrubs, fencing, or any other obstacles that should be replaced after the manhole has been raised and the job completed.

2. Dig down and completely expose the lid.

3. Remove lid for inspection. Be sure the casting is not offset from the grade rings or cone.

4. When the casting position has been determined, replace the lid on the casting.

5. To determine how far the manhole should be raised, use a straight rod or 2 x 4 board long enough to span the cut around the manhole. If the distance is three inches or more, a grade ring should be used. The two common ring sizes are 3 inches and 6 inches in height and are 4 inches wide.

6. Begin to remove the dirt from the outside of the casting down to the depth needed. The width of the trench around the casting should be 10 inches to 12 inches --- wide enough for a round point shovel.

7. If the manhole is 12 inches or more below the surface of the yard, lawn or road, then the cut of the trench around the manhole casting may have to be 18 inches or more. This is to provide a safer working area and to provide standing room down alongside of the casting in order to lift and remove it from the hold.

8. The casting is lifted from the manhole and set aside in a safe place where it will not slide back into the hole or cave in the side of the trench. WARNING. Manhole castings and grade rings are very heavy and care must be exercised when lifting and moving them either by hand or with lifting equipment.

9. Clean the top of the cone or grade ring and the bottom plate of the casting. To clean these surfaces, use a wire brush and scraper. Remove all dirt and any loose cement or rust.

10. Wash all surfaces including the casting plate, both sides of the grade ring and the cone. Use water and a brush.

11. Mix the grout (suggested mix: 5 sand to 1 each cement type two). Blend to an even texture. Add water to the mixed sand and cement. Blend to the consistency you desire to maintain the slump you feel would be necessary for the thickness required by the manhole lid being raised.

12. If the raise is less than three inches, but more than one inch, manhole spacers (Fig. 6.37) should be used. Spacers may consist of small pieces of red brick, presoaked broken concrete, or small redwood blocks. These should be placed in a manner to balance the casting with the street or ground level.

13. The grade ring should be moistened on both sides just before setting the ring down on the fresh grouted cone or grade ring.

6.513 Raising the Frame and Cover (Fig. 6.38)

1. One worker (Maintenance Man I) gets down alongside the cone or grade ring and using a brush or rag, wets down the cement surface. The worker is now ready for the grout.

2. The second worker (Maintenance Man I) furnishes the first worker with the grout in a shovel or a bucket. (Note: The worker placing the grout and shaping it should always wear rubber gloves for skin protection). Place the grout around the edge with both hands, covering the complete old surface of the cone. Use your hands to form and shape the grout to the desired height. Try to keep the grout fairly uniform. Prevent all or as much excess grout as possible from falling down into the manhole by placing cover boards over the channel and shelf in the bottom of the manhole. This procedure will be repeated again when installing grade rings.

3. After the desired height of the grout has been reached, wet down the bottom of the casting plate or frame.

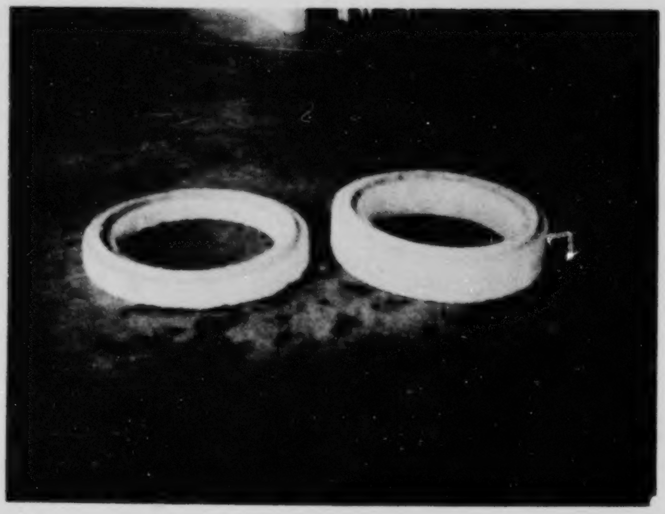


Fig. 6.37. Manhole spacers.

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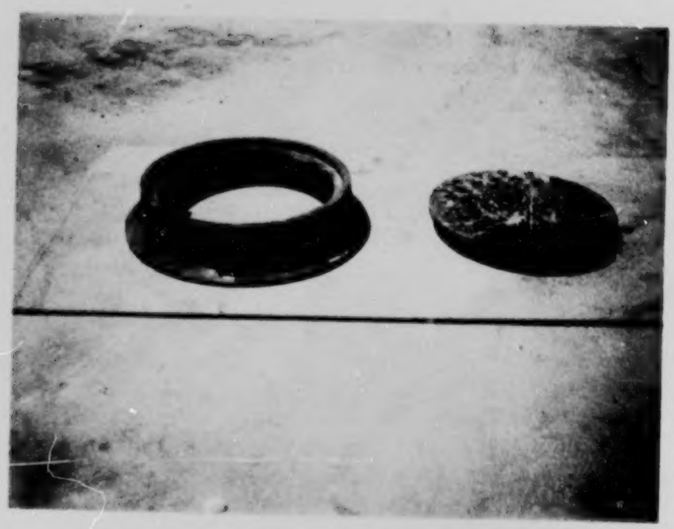


Fig. 6.38. Manhole frame and cover.

4. To set the casting, two workers are needed in the hole along the outside edge of the cones. Slide the casting as you pick it up from the edge of the ditch. Center it and place it on the grouted area. Make sure the casting opening is centered with the cone opening.

5. Use a straight edge to level the casting with the surrounding surface. Using a bar or sledge hammer, tap lightly on the top edge of the casting to obtain the exact level. This procedure also will squeeze out the excess grout.

6. Feather the excess grout around the casting and cone, using your hand or a brush. This should leave a smooth, clean finished surface. Remove all excess grout and place it on the outside edge between the casting and cone to form a seal from the outside. Cap the topside bottom of the casting plate with one inch of grout mix and overlap down to the cone or grade ring.

7. Backfill around the casting. After about four inches of dirt has been placed around the casting, tamp the dirt by walking on it for compaction.

8. Place the lid on the casting carefully. Continue to backfill and walk on the dirt for compaction. If backfilling more than one foot of soil, use some water to improve compaction. After backfilling and compacting, clean up excess dirt and haul it away to a disposal site.

9. Replace all lawn. Cut out an opening to keep the lid exposed. Replace shrubs in a manner that will not completely hide the lid or make it difficult to work in or around the manhole.

10. If fencing was removed, replace and cut notch out of the bottom board if it crosses the lid so the lid can be removed and replaced without any problems. Notify property owners of the notch in the fence.

Manhole lids in the street are raised following the same procedure, except we would use fast drying cement rather than sand and cement. Compaction and backfill around the manhole with air tamper or mechanical compactor to within four inches of the road level.

Use pre-packaged concrete or asphalt to fill the last four inches. Compact with an air tamper to finish grade. This procedure omits having to leave barricades in the traffic lanes. Also traffic can resume traveling over the freshly raised manhole.

Manhole lids also may be raised by excavating around the tapered cone, removing the tapered cone, frame and cover, installing a section of a reinforced concrete manhole barrel of desired length, replacing the cone section, and adjusting the frame and cover to the desired grade by using a minimum of brickwork. Sometimes manhole covers have to be raised two to three feet above grade in isolated areas to keep vandals from dumping large boulders and tree stumps into manholes.

Very often manhole lids must be raised because the manhole has settled. When manholes settle, sewers connected to a manhole may crack or break and the connection joints may develop leaks. Repair these problems when raising manhole lids and conducting other manhole repairs.

Industry has developed a special manhole casting which fits into existing lids and can be adjusted vertically to correct grade. This casting allows manhole covers to be raised before streets are paved and can be tilted if the pavement slopes.

QUESTIONS

6.5A Why do the lids of manholes have to be raised?

6.5B How are paved-over manholes located?

6.5C How is the height the manhole should be raised determined?

6.5D When the casting is lifted from the manhole, where should it be placed?

6.5E How can the top of the cone or grade ring be cleaned?

6.5F Why should the worker placing the grout and shaping it wear rubber gloves?

6.5G What should be done with fences over manholes?

6.52 Repair of Manhole Bottoms

Most manhole repair problems are discovered by preventive maintenance crews and are assigned to the repair section for correction in the form of work orders. This section describes procedures for inspecting and repairing manhole bottoms.

After all safety precautions have been taken by the three-worker crew and the manhole has been purged with fresh air, the manhole is washed down from the casting down to and including the bottom. This will usually clear the walls of material such as mud, grease, or other debris. Washing also helps clean out spiders, centipedes and other annoying pests. Run the blower at all times when there is a person working in the manhole (See Chapter 9, Section 9.5, Manholes and Other Confined Spaces).

After washing is completed, one worker (Maintenance Man I) will enter the manhole with proper safety equipment using a secure ladder. Inspect the casting, grade rings, cone, and barrels for seepage, deterioration and cracks. Once on the manhole bottom, inspect the condition of the channel to determine what action will have to be taken to correct any flow or leakage problems.

Problems encountered at the bottom of manholes range from no bottom to improper channels such as flat bottom, basin bottom and low inflow invert elevation to high outflow invert elevation that causes a sump or backwater problem. These problems are usually found in older sections of a wastewater collection system.

The following is a list of methods that can be used to correct each type of problem.

6.521 Manholes Without Concrete Bottoms

To start repair, if possible, plug off all incoming lines. If not possible, bridge a channel or channels across manhole bottom to allow flow to continue. Use half pieces of thin metal forms or plastic pipe to provide channels. Once channels are in place, probe the bottom to determine how much debris will have to be removed. Remove as much of the liquid portion of waste as possible in a bucket and remove from manhole for hauling off to a disposal site. Clear enough depth in bottom of the manhole for at least two and if possible, three feet of cobble stone, approximately four inches in diameter, for base fill. Leave at least a ten-inch space below form or the bottom of pipes to provide a firm footing.

Cover cobble rock with four inches of crushed rocks (3/4-inch to dust). After all this has been done and base is determined to be solid, inspect forms and make any necessary adjustments.

Spray rock base with water. Mix concrete to suitable slump. Pour the base by starting under the forms and carefully tamping under and up the side of the forms. This should prevent honeycombs and pockets. Once this is done, continue to pour until you have reached the amount needed to complete one side of the shelf and channel. The shelf slope should drop at least one inch and not more than 2 inches from the back wall of manhole to the top of the edge of the channel.

Place a knee board over finished shelf to stand on while pouring the rest of the manhole bottom. When the remainder of the bottom is finished, carefully stand on or in the pipe channel form. Remove knee board and touch up lightly by brushing entire bottom to remove the trowel marks and produce a brush or broom finish. Forms should not be removed for at least 36 to 48 hours to allow time for the concrete to harden and cure. After allotted time, remove forms and inspect the channels for any honeycombs. If honeycombs are observed, use quick setting cement to fill void areas.

To reduce the need for forms to shape the channel bottom, cut a section of plastic pipe or other type of sewer pipe in half to fit the invert and cement it into place. Advantages of this procedure include having a smooth flow channel and not having to worry about the concrete channel deteriorating and causing turbulence which can release odors.

QUESTIONS

6.5H Why should manhole walls be washed before inspection?

6.5I What types of problems are encountered at the bottom of manholes?

6.5J What is the first step to start repair of a manhole with no bottom?

6.5K What kind of base is provided in the bottom of a manhole without concrete bottom?

6.5L Why should the concrete surface on the bottom of a manhole be brushed or broomed?

6.522 Manholes With Flat Bottoms

Flat bottom manholes do not have channels through the bottom and are fairly easy to correct because the base is already in place.

1. First plug off all incoming lines, if possible. Another approach is to install a smaller pipe with the ends of the pipes sealed to the ends of the manhole inflow and outflow pipes in order to carry flow through the manhole. Clean, scrape and brush the bottom.

2. Remove plug or plugs, form channel with half pieces of tin, plastic pipe forms, or half sections of sewer pipe and repeat process from "no bottom manhole". Start with the procedure for pouring concrete and follow the steps with pouring to the finishing of the concrete. Remove forms 48 hours later if half sections of sewer pipe were not used.

3. Step 2 above may be replaced by use of speed-crete, once the plug or plugs are removed, the speed-crete can be used to form and shape the new channels. This process is by far the fastest and more practical procedure, with the exception of using half sections of sewer pipe.

   The speed-crete is mixed by the worker topside, lowered down in a rubber bucket to the worker in the hole who works quickly and sets the material in place. This worker shapes the speed-crete with both hands, forming a wall about an inch thick to the desired height and shape needed for the proper flow. Any rough spots can be shaved with a tuck trowel. A wet rag or wet sponge can be used to wipe down the walls of the formed channel to provide a smooth finish.

4. Now that the channels are formed and set, start with a speed-crete and pea-gravel mixture. Mix to same consistency as concrete. Pour and trowel to desired finish. Pea-gravel is used to reduce the amount of speed-crete which would usually be needed and makes the fill-in stronger.

   NOTE: Speed-crete is not a cement. It is aluminum and plastics and has a much higher resistance to acids and sulfide that makes this a much more practical material to use in building manhole bottoms.

   Pour the mixture to the desired height, usually 2 inches above the top of the pipes. Shape and finish one side. Now stand in the formed channel and pour and finish the shelves of the manhole.

6.523 Channel Corrections

Channel corrections are made to relieve flow problems such as the tee-shaped channel. This type channel is called "dead-heading", which means the flow runs directly into the main channel flow. This causes a turbulent flow and can restrict the flow from incoming lines.

Tee-intersections can be corrected by cutting off one corner of the tee-shaped channel. Use a jack hammer and cut down below the flow line. Use speed-crete and reshape the channel into a smooth wye shape. This will channel the flow in the same direction as the main flow.

Basin channels are usually found on incomplete channel bottoms. This channel usually starts 6 to 12 inches from the wall of the manhole and then feathers out into the basin. The flow correction again can be made by forming speed-crete for the proper channel shape. Fill in behind the new channel with a speed-crete and pea gravel mixture. Form the shelves of the manhole too.

QUESTIONS

6.5M How are channels formed using speed-crete?

6.5N How are smooth channel surfaces obtained when using speed-crete?

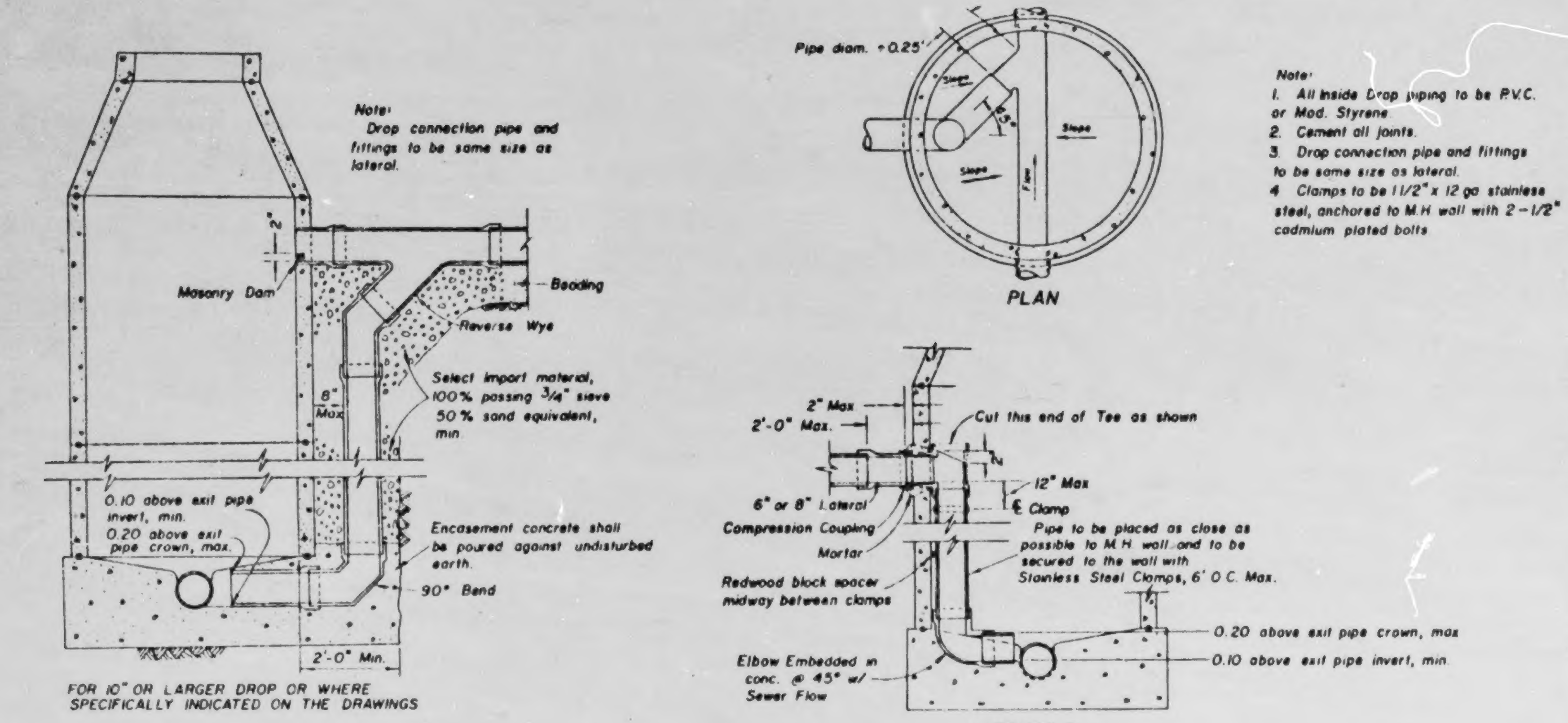
6.5O Why does speed-crete have a higher resistance to acids and sulfide than concrete?

6.5P Why are channel corrections made?

6.5Q How are channel corrections made?

6.53 Inside Drop in Manholes (Fig. 6.39)

A main line or house service line lateral entering the manhole at a higher elevation than the main flow line or channel causes splashing odors and difficult working conditions. These lines should have inside drop pipes connected to them. The inside drop



Note:
Drop connection pipe and fittings to be same size as lateral.

FOR 10" OR LARGER DROP OR WHERE SPECIFICALLY INDICATED ON THE DRAWINGS

Note:
1. All Inside Drop piping to be P.V.C. or Mod. Styrene.
2. Cement all joints.
3. Drop connection pipe and fittings to be same size as lateral.
4. Clamps to be 1 1/2" x 12 ga stainless steel, anchored to M.H wall with 2 - 1/2" cadmium plated bolts

2"
Masonry Dam
Bedding
Reverse Wye
Select import material, 100% passing 3/4" sieve 50% sand equivalent, min
8" Max
0.10 above exit pipe invert, min.
0.20 above exit pipe crown, max.
Encasement concrete shall be poured against undisturbed earth.
90° Bend
2'-0" Min.
Pipe diam. + 0.25'
Slope
Slope
Slope
Flow
45°
PLAN
2" Max
2'-0" Max.
Cut this end of Tee as shown
12" Max
℄ Clamp
6" or 8" Lateral
Compression Coupling
Mortar
Pipe to be placed as close as possible to M.H. wall and to be secured to the wall with Stainless Steel Clamps, 6' O.C. Max.
Redwood block spacer midway between clamps
0.20 above exit pipe crown, max
0.10 above exit pipe invert, min.
Elbow Embedded in conc. @ 45° w/ Sewer Flow
PROFILE

OUTSIDE DROP CONNECTION

INSIDE DROP CONNECTION

Fig. 6.39. Inside and outside drop connections.

line consists of a tee attached to the incoming pipe and should fit flush against the manhole wall. A length of pipe runs from the tee to the manhole bottom and a 90-degree elbow directs the flow into the channel at the correct angle. If possible, service lines should be connected to manholes as outside drops, but inside drops are more economical after the system is completed.

6.531 Materials Used for Inside Drops

The most suitable pipe and fittings used for all inside drop lines into a manhole up to twelve inches in diameter is plastic class 125 pipe. The class 125 plastic pipe has worked very successfully for inside drop lines. Examples of use include from 4 inch up to 12 inch inside drop lines, including discharge drops at the end of force mains.

6.532 Installation of Inside Drops

1. Use a jack hammer, drill hammer and chisel to chip out concrete around the incoming pipe and back into the wall of the manhole at least 2-1/2 inches. Set the tee fitting into the opening at a vertical angle. The tee should line up with the pipe and fit tight against the wall.

2. Set a plumb line to the manhole bottom shelf to determine where the 90-degree angle will set. If possible, use the jack hammer and cut a channel with the proper angle to insure correct flow with flow in the main channel.

3. Measure the distance from the tee to the 90-degree angle to determine the length of pipe needed. Glue fittings to the pipe and set in place. Recheck for alignment. Use speed-crete to cement tee into the wall, to anchor the 90-degree angle into place, and to finish the new channel. The tee should be strapped to the wall. If the drop pipe is more than 8 feet, this pipe also should be strapped to the wall of the manhole.

4. Force main discharge drop lines should always be double strapped to the wall around the tee fitting or a sanitary tee. The 90-degree angle at the bottom of the drop line should be channeled in as close to the flow line as possible to prevent any spray or splash.

6.54 Repair of Manhole Barrels

Repair of a manhole barrel depends on what is wrong with the manhole, the condition of the manhole, and the circumstances under which the repairs must be made. To repair cracks or leaks in a manhole barrel, several techniques are available:

1. Patching
2. Grouting
3. Lining

Patching is done with a fast-drying cement and usually under adverse or wet conditions. Grouting also uses a fast-drying cement. The grout is either applied by hand or sprayed over the surface being repaired.

Lining a manhole consists of either inserting a liner or spraying a lining material over the manhole barrel. A piece of pipe can be inserted in a manhole as a liner. The pipe could be made of plastic, tile or bricks. Grout is placed in the space between the manhole and the pipe. A liner such as an epoxy or fiberglass may be sprayed over a manhole barrel. The surface of the barrel must be dry before spraying.

QUESTIONS

6.5R Why are inside drop lines installed in manholes?

6.5S What is an inside drop line?

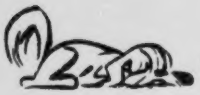
6.5T How are inside drop lines secured?

6.5U What material is used for inside drop lines?

6.6 NEW CONSTRUCTION

Occasionally a crew may be required to extend a line a short distance and install a new cleanout or manhole. The procedures for new installations are similar to repairs, except usually the problems created by wastewater flowing in the existing system are not present.

For additional information on new construction procedures, read Chapter 3, SUPPLEMENT, on construction, inspection and testing.



END OF LESSON 2 OF 3 LESSONS
ON
UNDERGROUND REPAIR
AND NEW CONSTRUCTION

DISCUSSION AND REVIEW QUESTIONS

Chapter 6. Underground Repair and New Construction
(Lesson 2 of 3 Lessons)

Write the answers to these questions in your notebook before continuing.

7. Why should repair assignments be made using work order forms?
8. What must be done before repair work on a sewer is started?
9. When should hard hats be worn and why?
10. How would you install a cleanout in an easement?
11. How would you replace a tap full of roots in a main line located in a street?
12. During excavation, how would you attempt to look for the location of unknown underground utilities?
13. What types of repairs are likely to be needed by manholes?
14. How would you raise the lid or cover of a manhole?
15. How would you repair a manhole without a concrete bottom?

CHAPTER 6. UNDERGROUND REPAIR AND NEW CONSTRUCTION

(Lesson 3 of 3 Lessons)

6.7 POLYETHYLENE PIPE LINING

6.71 Why Line Sewers?

Polyethylene pipe lining is a repair method accomplished by inserting polyethylene pipe into the existing sewer system.

Liners can be an effective method of pipe repair or reconditioning of the sewer system. Frequently liners are installed to control excessive infiltration, exfiltration and root intrusion. Selection of this method depends on whether this procedure is simpler, quicker and more economical in comparison with other techniques available to solve the problems in the sewers.

6.72 Preliminary Work

Before attempting to do any "slip lining", there are some very important items to consider. Identify the area to be "slip lined" and carefully review available records and maps of the area. Plan the operation on a step by step basis.

Send to each home owner a typewritten letter explaining why the project is necessary, what is planned and what is expected to be accomplished by the operation. The letter should indicate that the home owenr could be temporarily inconvenienced during construction and also explain the benefits that will result from the completed project. Advise the home owner of any direct costs that must be paid. Send along with this letter a form, legally prepared, for the home owner's signature. This form provides authorization to do any and all work necessary to accomplish the job. It also quarantees that the premises will be restored to as near its original state as possible at no additional cost to the home owner.

Take photos of the yards around each house that may be affected by the job. This provides a picture record of the appearance of the premises before the work is performed. If necessary, a comparison may easily be made when the work is completed.

Notify all of the utility companies in the area and request them to locate and mark all of their underground lines in the area.

Televise the main line and prepare a record showing the location of each lateral, any misaligned joints and any other discrepancy which will need to be corrected before the actual lining takes place. The lateral locations are later marked on the street surface.

A pre-measuring study gives the amount, size and type of material needed to do the job. An order is placed for the material. The list of materials should include plastic pipe for both the main line and the laterals, tee saddles, couplings of the various sizes needed and materials for the cleanouts to be installed on the lateral near the house.

6.73 Equipment

The equipment needed to do the job should include a back hoe for excavating, cable winch for pulling the pipe through the main line, pneumatic equipment for pavement breaking and compacting the backfill. Also needed are dump trucks, a utility truck for transporting material and small tools, and a flat bed truck with a specially constructed rack for transporting the 40-foot lengths of pipe and plastic fittings. This truck carries on it the equipment required for fusing the plastic pipe together, a generator which provides the power needed to operate the heating elements and other electrical equipment. The generator should be capable of producing at least 2,500 watts.

Equipment used for preparing and welding the pipe together should include fusion joiner jigs and mobile carts to handle both the main line size pipe and laterals, a butt fusion tool or squaring tool and heating faces (both flat and part round) for heating the saddles. Tapping or coring tools are needed plus whatever accessories used for the adaptation to the various size pipe that will be used and the pulling heads.

6.74 Inserting Liner in Main Lines

Be sure all misalignment and other problems have been corrected before starting the lining job.

Transport all material and equipment to the job site. Hold a brief group discussion to review the operation and safety considerations. Cones and safety warning devices are set up; and, once a proper traffic control pattern is established, the actual work is ready to begin (see Chapter 4, Section 4.11, Traffic Safety).

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4:11 ON PAGE 4-2

While one crew assembles the liner, the excavating crew begins digging the pull hole at a pre-determined location. Pulling distances will vary in accordance with the job conditions. A third crew prepares the pulling equipment and pulley apparatus in the manhole into which the liner will be pulled. The pulling hole will be approximately 30 feet in length and as deep as the main line. The depth of the main line greatly determines the length of the pull hole. Once the pull hole is dug and the main line exposed, a high velocity cleaner is used to be sure the main line is clean. The main line in the pull hole is then broken and a high velocity cleaner is sent through the line to clean the pipe and at the same time pull the winch cable from the manhole to the pulling hole. At the pulling hole, attach the winch cable to the special pulling head which is welded on to the pipe liner.

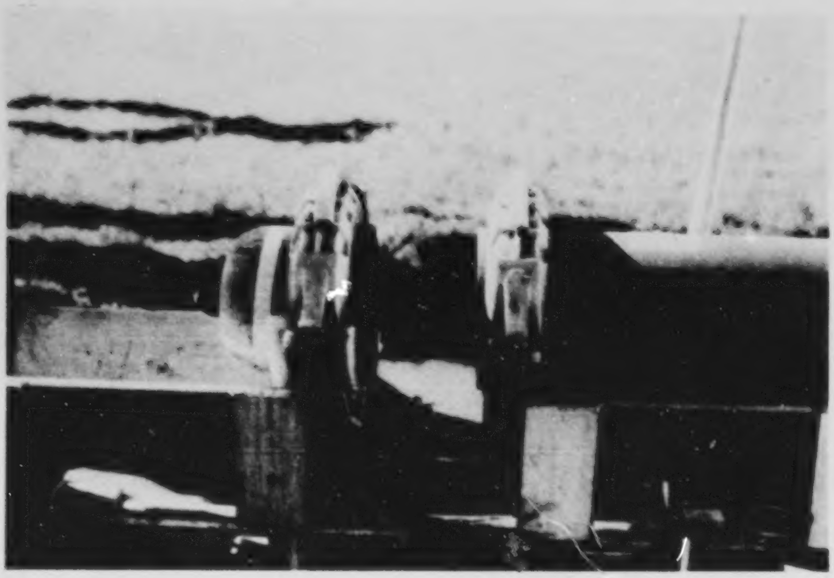
Weld together the amount of pipe for this particular pull and weld on the pulling head (Figs. 6.40, 6.41 and 6.42). Use a fusion jig and mobile cart to weld the material together. The two pieces of pipe to be joined together are placed into the jig and a squaring tool is used to true the ends of the pipe to be joined together. Once this has been accomplished, the heating face is brought to the proper temperature - 500 degrees Fahrenheit (260°C). The pipe ends are simultaneously heated until a small bead begins to form. The pipe is held to the heating face for 10 seconds after the bead is formed. Snap off the heating face and butt the two ends together. Hold together for approximately one minute. The joint is left to cool for at least 3 minutes before the operation is repeated. In order to insure proper melt, the temperature of the heating faces should be 500 degrees Fahrenheit. Tests have shown that the pipe is actually stronger where the weld has been made than at the run of the pipe.

Once the required joints of pipe have been welded together and the pulling head attached, the pipe should be chalk or crayon marked at 50-foot intervals. This is a precautionary measure. In case there is a pulling problem and the pipe hangs up in the line, it becomes necessary to dig up the pipe. By marking at 50-foot intervals, the pulling head is easily located in the line. Hopefully, there will be no problems.

When all has been made ready (Fig. 6.43) and the cable has been attached to the pulling head with a clevis, the actual pulling begins. The winch operator is signaled, a worker is stationed in the pull hole to keep the pipe smoothly guided into the pipe and the pull begins (Fig. 6.44). Providing that there are no problems, the pull will be over in a few minutes.

Once the pulling head comes through at the manhole where the pull is made, the cable is removed and the pipe is "whipped in" (hammered in with a sledge to take up the stretch of the pipe which may occur during the pull) (Fig. 6.45). The pulling head is then cut off to be reused and preparation for insertion of liner into laterals is begun.

Whenever there is occasion to pull the liner through a manhole, the upper half of the liner is cut away, leaving the lower half to serve as a channel in the manhole. The manhole must be sealed around the opening in the liner. Sometimes the liner is removed and a new channel bottom is installed during the sealing operation.



Pulling head ready to be welded onto pipe.

Fig. 6.40. Attaching pulling head
(Courtesy of Napa Sanitation District)

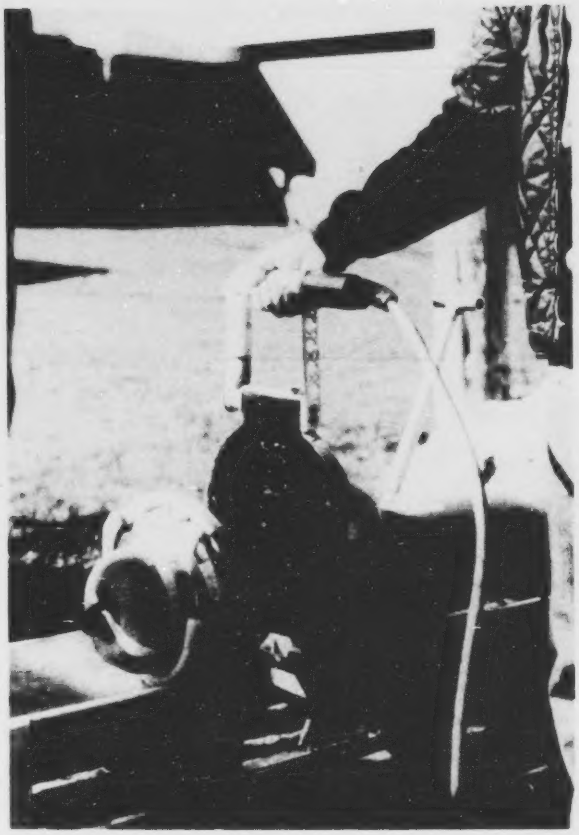


Fig. 6.41. Heating face to be applied to pulling head and pipe. (Courtesy of Napa Sanitation District)

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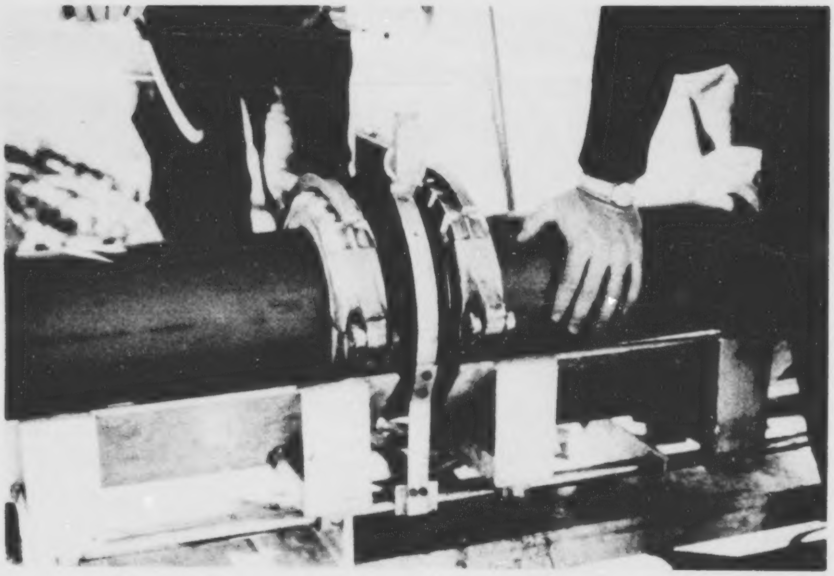
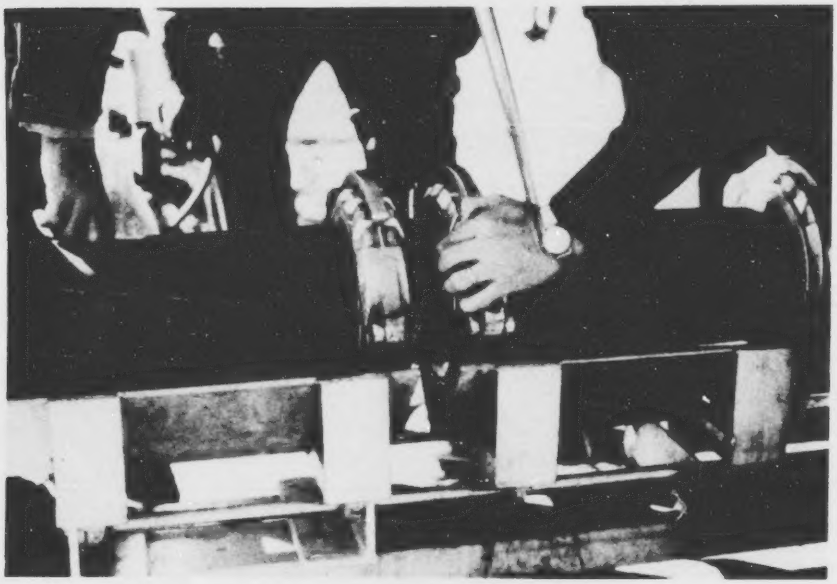


Heating ends of pipe



Fusing ends of pipe together

Fig. 6.42. Fusing pipe together.
(Courtesy of Napa Sanitation District)

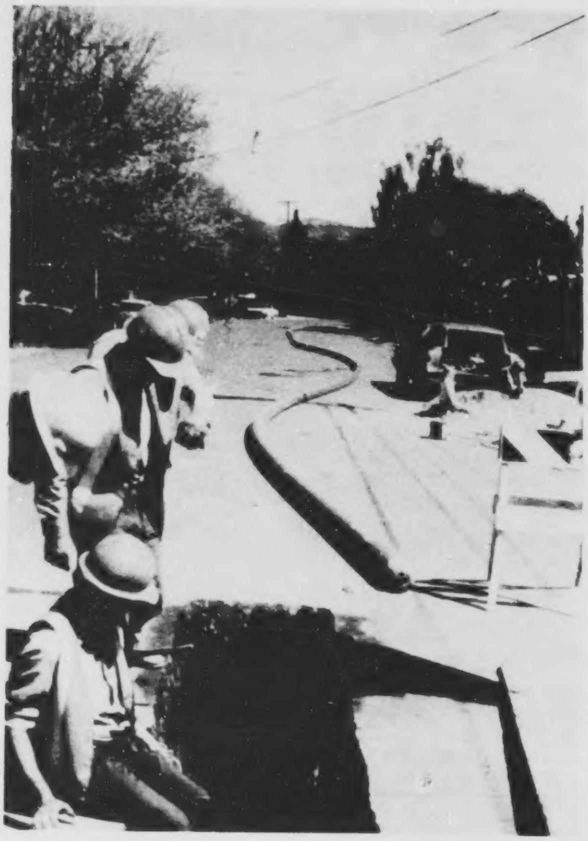


Fig. 6.43. Pipe fused together ready for pull
(Courtesy of Napa Sanitation District)

Fig. 6.44. Walking the pipe liner in.
(Courtesy of Napa Sanitation District)

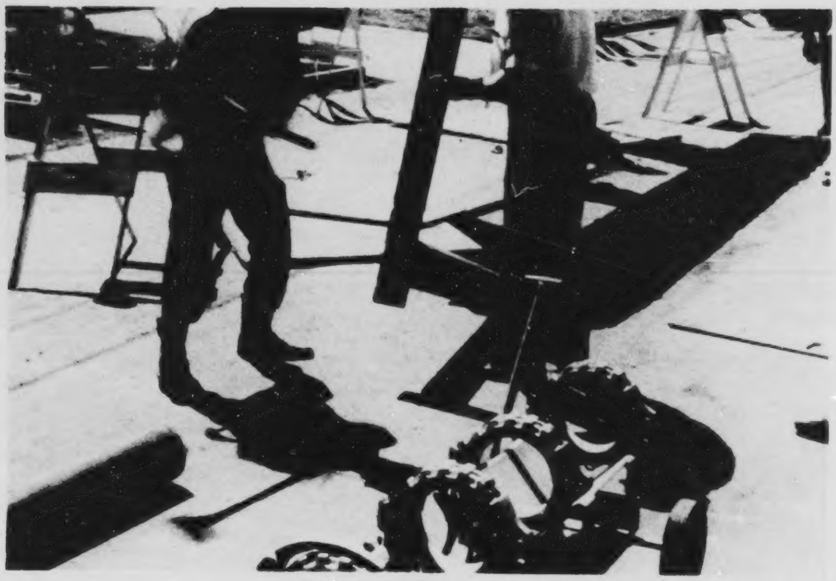


Fig. 6.41. "Whipping in" the pipe after pull. (Hitting end of pipe that is protected by a board with a sledge hammer).

The annular space between the outside diameter of the pastic liner and the inside diameter of the old sewer line, in most cases, is sufficient to handle the wastewater which is introduced into the system through the old connections until the entire operation of installing new laterals has been completed.

QUESTIONS

6.7A How do liners repair or recondition a sewer system?

6.7B What information is included in a letter to home owners explaining a "slip lining" project?

6.7C Why should a sewer be televised before "slip lining"?

6.7D What equipment is needed to weld polyethylene pipe together?

6.7E How many crews are recommended and what are their duties for a "slip lining" project?

6.7F Why should the liner be marked at 50-foot intervals before being pulled into the sewer?

6.75 Inserting Liner in and Connecting Service Laterals

6.751 Procedure Lining Service Laterals

The method employed in this operation will vary, depending if the existing service lateral will be connected to the polyethylene main or if the lateral itself will be renewed completely.

Considerable infiltration could enter the collection system through breaks or bad joints in laterals. Determine if laterals need "slip lining" and, if necessary, follow the procedures outlined in this section.

Procedures used to "slip line" a lateral are similar to the procedures used to slip line the main line. A pushing hole, instead of a pulling hole, is dug at the main where the old service lateral made its connection (Fig. 6.46). Also, a hole is excavated at the house and the lateral is exposed and broken at both ends. The desired length of pipe is fused together. A nose cone is welded on to the tip which will be inserted into the old lateral. The old lateral is checked and a swab is pulled through to make certain that it is free of grit and roots and to locate any bad obstructions.

Fig. 6.46. Street cut for service lateral.
(Courtesy of Napa Sanitation District)

When all has been prepared, the new lateral is pushed from the push hole at the main line to the hole near the house. The lateral is aligned to the main, a saddle is welded on at the main and, after it has cooled sufficiently, it is cored and the connection is made (Fig. 6.47).

The excavation at the main line then should be backfilled. To minimize the possibility of the pipe and lateral getting out of round at this point or egg shaping in anyway, the area beneath, alongside and over the pipe is packed with fill sand and the balance of the hole is backfilled with a granular backfill, carefully compacted in lifts of one to two feet. The streets are then paved.

6.752 Installing Cleanouts

The fittings to be used for the cleanout connection to the lateral at the house are assembled. Basically, these include a 3-inch combination wye and 1/8 bends, a 3 inch to 4-inch reducer, a plastic cleanout cap, a christy box[7] which will be used as the cleanout point, and the assorted couplings needed to make the proper connections.

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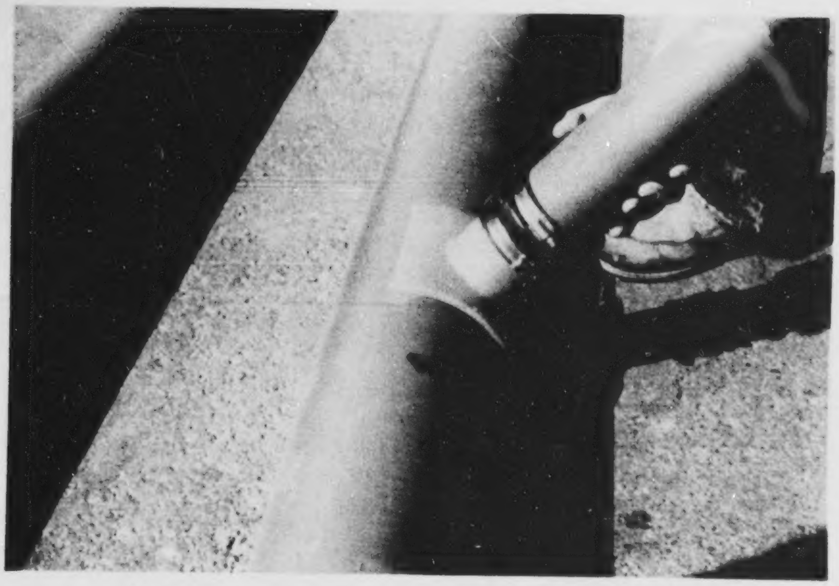
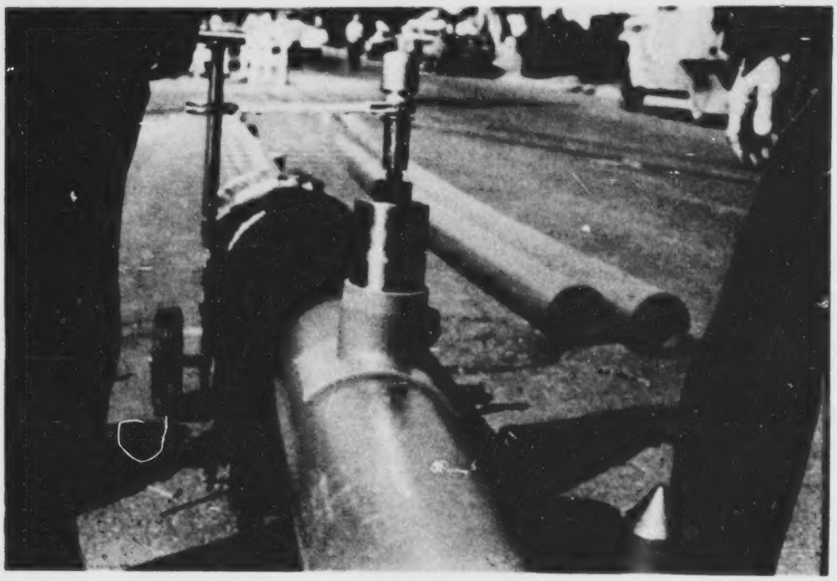
[7] Christy box. A box placed over the connection between the liner and the house sewer to hold the mortar around the cleanout wye and riser in place.



Inspecting the saddle



Saddle and coring tool

Fig. 6.47. Saddle for lateral
(Courtesy of Napa Sanitation District)

When all of the tools and material are assembled to install a cleanout, the nose cone is cut off. The fittings are installed and the connections are made at the house. The riser is then connected to the 1/8 bend of the combo wye, cut at the desired height which normally will be several inches below the ground or lawn level. The christy box is put into place and the inside is mortared to within one-half inch of the top of the riser. A plastic cap is placed on the riser, the lid is placed on the christy box and this operation is complete. Backfill lawn areas with loam and plant new lawns in areas which have been disturbed.

6.753 Installing Tee Saddles

There are various ways of installing the saddle to the main line. Using mortar, banding and welding are a few. Fusion welds provide a good seal and a strong connection and will be described in this section.

The main line is exposed at the point where the tee saddle will be located. The old pipe is broken and completely removed, leaving the plastic liner exposed. A well hole is dug large enough to allow room to work with the apparatus needed and to keep the hole free of water if necessary. The pipe is carefully cleaned and the glossy surface is sanded. The saddle is positioned in the approximate place where it will be welded. "Mark in" the saddle with crayon. The saddle is then placed in the saddle holder and onto the heating face. Once the saddle on the face is at the desired melt point, it is then placed face and all onto the main line which had been marked. Both the main and saddle are heated simultaneously. When the desired melt on both pieces is reached, the heating face is removed from the line, the saddle is snapped free from the heating face and pressed onto the main line. When the weld has cooled sufficiently, the main line is cored and the lateral is connected to the saddle by means of a coupling.

The pipe is then packed and bedded in fill sand. The remainder of the hole is backfilled and compacted with granular backfill and the street is paved.

6.76 Sealing the Space in the Manholes

Infiltration must be prevented from entering the system at the manhole from the space between the new liner and the existing line. Part of the pipe through the manhole is used as a channel whenever possible. The procedure for sealing is easy. Use oakum rope soaked in a urethane sealing compound or chemical grout that is activated by water. Pack the soaked oakum rope into the space between the pipe and the manhole. Carefully pack the rope tightly into the space. Finish off the work with a quick set cement. The channels of the manhole should be properly shaped and the shelves of the manholes should be completed to give the proper pitch and finish.

The entire area is then double checked and policed to be sure that all phases of the job are complete. Once this has been accomplished, the operation is moved to the next area, set up for "slip lining" and the entire procedure is repeated.

6.77 Thank the Public

The project began with a letter and should end with a letter of thanks for the people's cooperation to each home owner which is signed by the Chairman of the Board of Directors or other appropriate official. Good public relations at this time can be very helpful now and in the future.

6.78 Additional Reading

"Lateral Connections with "Inserted" Polyethylene Piping," Water & Sewage Works, March 1975, pp. 66 and 67.

QUESTIONS

6.7G When "slip lining" laterals, where are holes commonly dug for the liner?

6.7H Why should cleanouts be installed near where a lateral goes under a house?

6.7I Why is the space between the liner and the manhole sealed?

6.8 POLYMERIC SEALING

Several methods or techniques are available today for internal grouting or sealing of sewer pipes. This section describes one technique - polymeric sealing. Other techniques are available and provide similar results. Polymeric sealing is used to illustrate the reasons for internal grouting or sealing and the procedures.

Polymeric Sealing is one method of internal chemical sealing. This particular method is a process that is designed to re-form the gasket of the leaking pipe, and seal at the site of the leak, rather than stabilize soil as in other sealing methods. The process utilizes a Urethane Pre-Polymer as the Sealing Chemical. This Urethane is catalyzed by water and forms a rubberlike compound at the leak.

Technology is continually developing newer and more effective sealing compounds. These compounds may seal the pipe joint or crack, or seal a leak and stabilize the soil, or possibly even chemically control roots, stabilize soil and seal a leak. Before selecting a sealing compound, try to identify the problem or problems you wish to correct, determine what compounds and procedures are available, discuss their effectiveness with other persons who have used the sealant and equipment, and select what you think will do the best job for your agency. For ideas on how to select a sealing compound and procedures, review Chapter 4, Section 4.44, Purchase of Closed Circuit TV Equipment, and Chapter 5, Section 5.22, How to Select Chemicals.

6.81 Reasons for Grouting or Sealing Sewers

Of the various sewer rehabilitation techniques used today, internal sealing is one of the most widely used methods. Internal sealing is effective when the sewer line to be repaired is in an area that is unsuitable for excavation, and is either infiltrating or exfiltrating through leaking joints, cracks, or small holes. Where the structural integrity of the sewer is gone due to collapsed sections or severe cracks or holes, sealing is not ideally suited to solving the problem. Under these conditions, structural repairs are necessary to insure structural stability before sealing the remaining parts of the sewer.

The sealing process consists of using a closed circuit television system and a packing device. The TV camera monitors the "packer" as it is placed on leaking joints in the pipeline. When the packer is positioned correctly, a pumping system is activated to inject the sealing chemicals into the leak. The use of internal chemical sealing does not require excavation, nor does it require the interruption or by-passing of wastewater except in extreme conditions. Sealing compounds have been developed which are so effective that well points do not have to be sunk to dewater the area and prevent washout of sealing compound.

The uses of sealing include rehabilitation of existing sewers to reduce infiltration/exfiltration and manhole sealing. Sealing processes also are used on new construction of sewer lines where the contractor is unable to pass the line acceptance test, be it either air testing, water testing or weir measurements. Sealing in many cases avoids further delays and costly excavation.

6.82 Equipment

Sealing equipment is generally used by two groups of individuals -- the agency, whether it be county, municipality, or utility district, and the contractor who specializes in TV inspection and sealing. Of the two groups, the contractor is the one who does a majority of the sealing projects. In either case it is a good idea to be familiar with the sealing process since most communities at one time or another will employ sealing whether through a contractor or with their own equipment.

The following list indicates the basic system requirements (Fig. 6.48) of the Polymeric Sealing System and briefly describes the use of each component.

Air Compressor - The system is air activated. Compressed air is used to operate the pumps and inflate the sleeve packer.

Chemical Pump - The sealing chemical is pumped through hoses down into the sewer to the sleeve packer.

Water Pump - Water (catalyst for the chemical) is pumped through hoses down into the sewer to the sleeve packer.

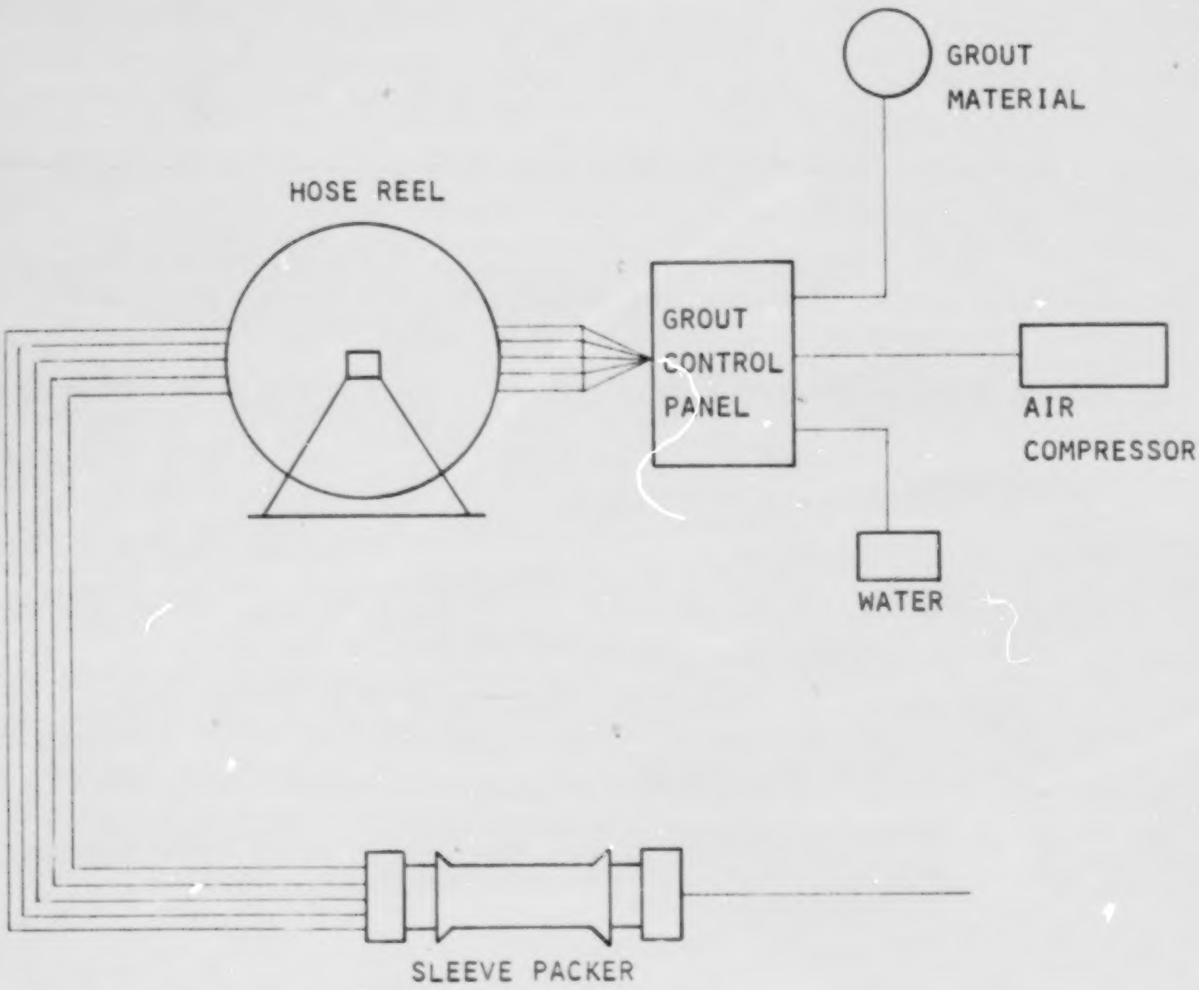

GROUT
MATERIAL
HOSE REEL
GROUT
CONTROL
PANEL
AIR
COMPRESSOR
WATER
SLEEVE PACKER

Fig. 6.48. Major components of polymeric sealing system.

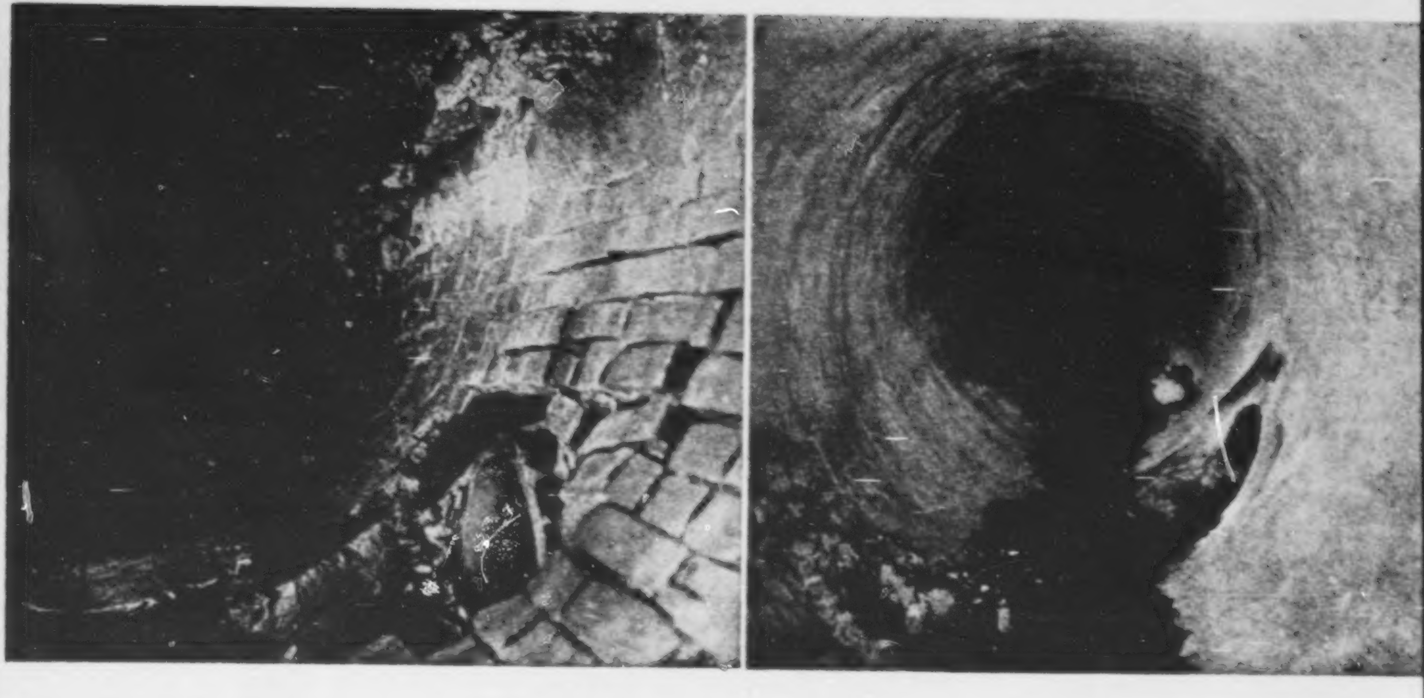


Fig. 6.58. Brick sewer before and after guniting.
(Courtesy of Pressure Concrete Construction Company)

Control Panel - The activation of the two pumps and the inflation and deflation of the packer are controlled from the panel. The entire sealing process is monitored and operated from this panel.

Sleeve Packer - The actual component that does the sealing down in the sewer. This component is inflated pneumatically to isolate the leak and forces the sealing chemical into the leaking area.

When using the Polymeric process it is unnecessary to mix the sealing chemical. It is pumped directly out of its shipping container and the water is pumped out of its container. As long as water reaches the Urethane Sealant Chemical, the reaction will occur.

While this list covers the basics of the system, there are other items involved such as interconnect hoses, assorted valves and fittings, a hose reel, and a penta hose[8] to carry the air and chemicals to the packer.

6.83 Sealing Chemical - Urethane Polymeric Sealant

The sealing material is a hydrophilic[9] polymer[10] which is applied to a sewer pipe joint or defect by use of the sleeve packer. The uncured material is an amber colored, translucent liquid that contains solids material constituting 82 to 88 percent of its total weight. The solids content plays an integral part in choosing a sealant chemical, since the sealing chemicals used today will shrink to the volume of the solid material if moisture conditions are not maintained.

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[8] Penta hose. A hose with five chambers or tubes.

[9] Hydrophilic. Water loving.

[10] Polymer. A high-molecular-weight substance that is formed by either a natural or synthetic process. Natural polymers may be of biological origin or derived from starch products, cellulose derivatives, and alginates. Synthetic polymers consist of simple substances that have been made into complex, high-molecular weight substances. Often called a polyelectrolyte.

When the Polymeric Sealing material is mixed with an equal quantity of water (a special accelerator is added for winter conditions), the material expands 10 to 12 times its original volume and cures to a tough, flexible, elastic condition. As a note, the chemical will absorb the water it needs to react, which is an equal volume, and dispel the remaining water in its immediate surroundings. As is the case in actual sealing operations, there is always excess water present when sealing leaks, but this excess water is not a dilution factor to the Polymeric Sealant as is the case with some other hydrophilic substances.

When cured the compound exhibits tensile strength of at least 90 psi and 800 percent elongation (can be stretched 8 times its original size or shape). The material does not change in linear dimension more than 18 percent when subject to wet and dry cycles. The Polymeric Sealant has the following properties:

1) Resistance to most organic solvents, mild acids and alkali.

2) Returns to shape after repeated deformations.

3) Essentially non-toxic in cured form.

4) Does not become rigid or brittle when exposed to freeze-thaw or dry or low moisture conditions.

5) Non corrosive and does not contain neurotoxic ingredients in either cured or uncured form.

90 PSI AND 800 PERCENT ELONGATION

Figure 6.49 below shows the approximate chemical quantities in fluid ounces of grout per pipe joint used to rehabilitate different types of pipes and different sized pipes. These quantities have been established by actual field experience, but may vary slightly depending on the condition of each specific joint. Factors which may affect the chemical quantities include original gasketing materials remaining in joint, open or offset condition of joint, or severity of infiltration or exfiltration.

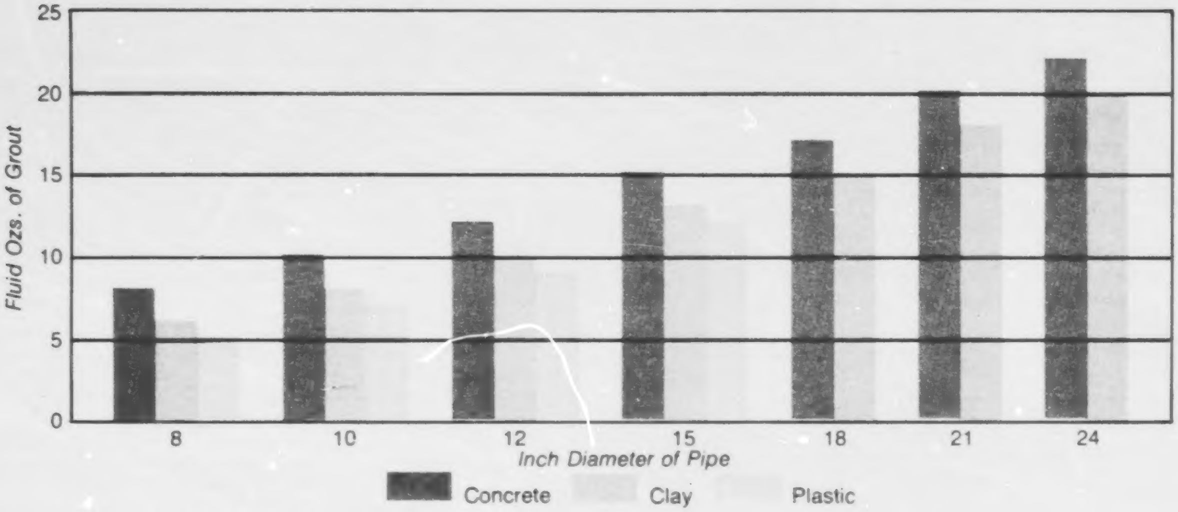


Fig. 6.49. Chemical quantities used for different pipe joints.

QUESTIONS

6.8A Under what conditions can grouting or sealing be considered an effective method to repair or rehabilitate a sewer?

6.8B What are the basic pieces of sealing equipment?

6.8C What are the properties of the Polymeric Sealant?

6.84 Sealing Process

This next section describes the Polymeric Sealing process on a typical 8-inch leaking joint. While this does not cover all aspects of sealing sewers, it does provide an adequate example of stopping the most commonly encountered leaks. Special leaks, extreme conditions, badly cracked pipes and other situations are best done with the consultation of the equipment manufacturer.

6.841 Set Up

The camera and sleeve packer are connected together with the camera turned around to look at the packer (Fig. 6.50). The air and chemical hoses are then connected to the sleeve packer and each mode is tested to insure operation before lowered into the line.

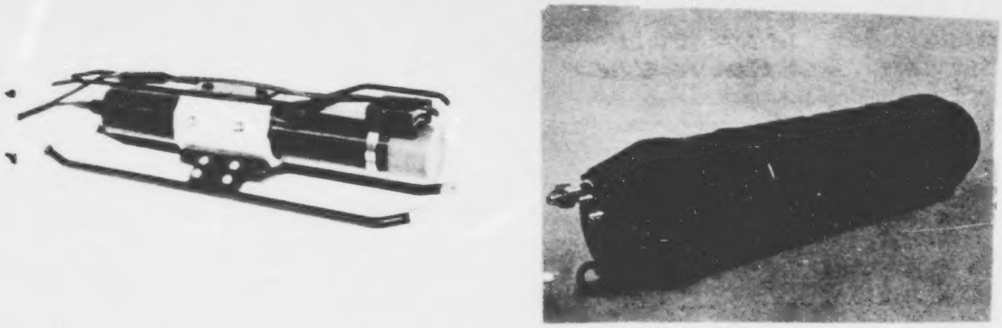


Fig. 6.50. TV camera and packer.

6.842 In Line

The camera and sleeve packer are then lowered into the manhole, and guided into the sewer line as the cable winch at the opposite manhole slowly pulls the units through the line (Fig. 6.51). As a note it is better to have the camera on the downstream side of the packer because the water build up cuts valuable time from the operation and obscures much of the visual inspection of the process. Manhole rollers and jacks are placed in the manhole to prevent gouging and scraping the hoses and cables as they move through the manhole.

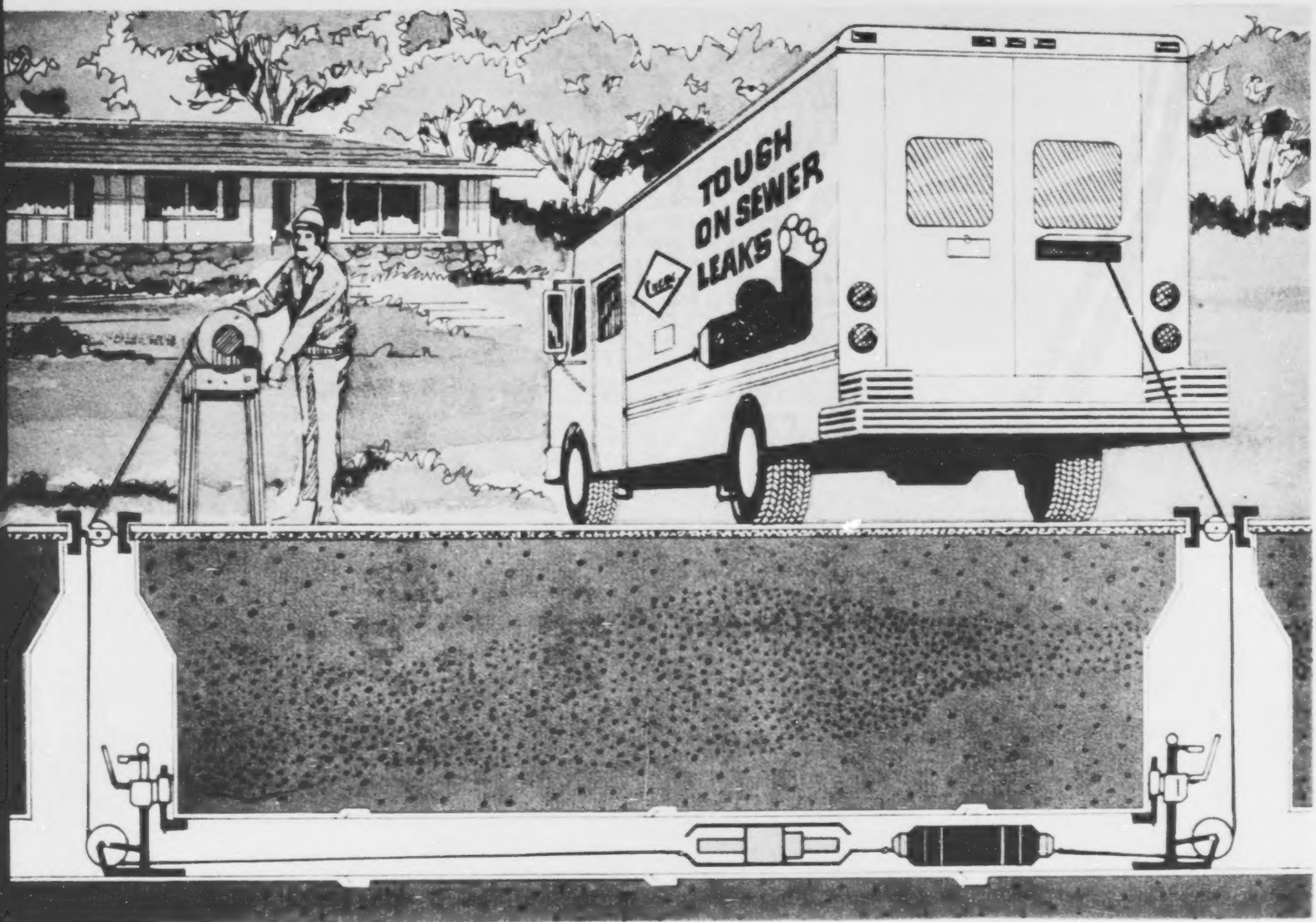

TOUGH
ON SEWER
LEAKS

Fig. 6.51. In line operation.

The camera and packer are then winched to the nearest leak to be tested or sealed.

6.843 Testing and Sealing

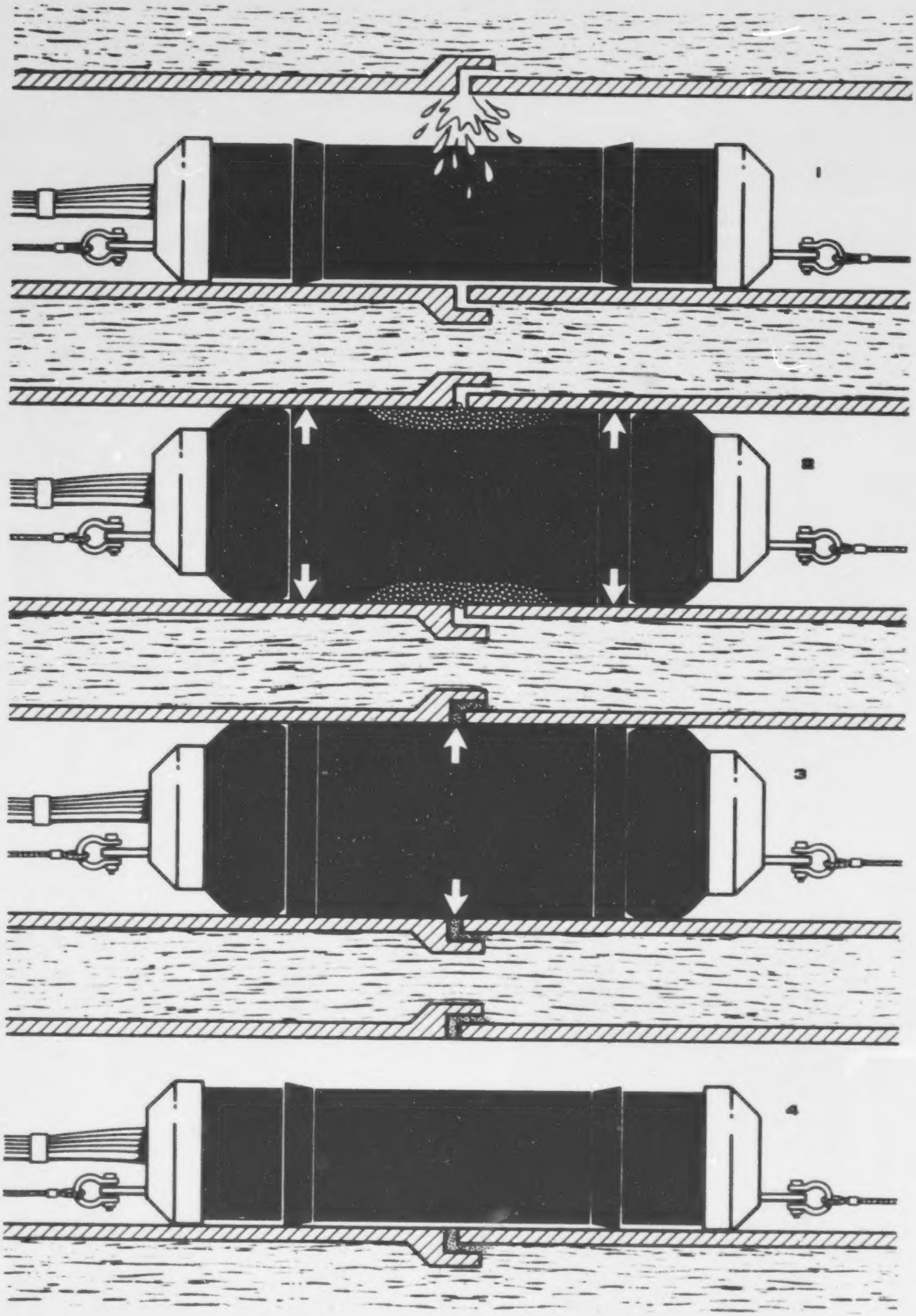
Once the sleeve packer is centered on the joint, the test may be run (Fig. 6.52-1). It is necessary to test only those joints where visible leaking is not evident. All leaking must be sealed. The first step of the test is to inflate the end elements. Water is then pumped into the isolated area formed by the inflation of the end elements (Fig. 6.52-2), and the pressure in the center area on the packer is monitored for an increase to ascertain the integrity and tightness of the joint. The pressure in the center area of the packer may be set any where from 0 to 15 psi depending on the depth of the line and water table condition.

Once a leak has been detected, either through visual observation or through detection from testing, the equipment is then placed into the grout mode (Fig. 6.52-2). Three (3) timers are set: one is the length of time that the chemical is injected, the second determines the reaction time from liquid to "foam", and the third timer controls the cure time. After these timers are set, the grout switch is pushed and the machine automatically pumps the chemical, allows it to react with water, and inflates the center area on the packer to squeeze the foaming chemical into the leak (Fig. 6.52-3). The sleeve packer is held in the inflated position until the Sealant is cured and then is automatically deflated (Fig. 6.52-4). A post-seal test may also be run to insure the joint has been effectively sealed to desired pressure.

The entire process will average out to about 5 minutes per joint when each joint is tested - sealed - retested. Winter time operations will take longer due to the extra freeze prevention precautions that are taken and due to the fact that the chemical will react more slowly as it gets colder.

6.844 Clean up

Once the manhole section of sewer has been sealed and tested to the engineers specifications, the camera and packer are removed from the line and clean up of the unit takes place. The hoses and cables should be wiped free of wastewater as should the camera and sleeve



Packer ball is positioned (1) and outer edges of ball inflated to isolate defective joint. Low pressure air introduced to isolated section confirms leak and grout material is inserted (2). Inflation of middle section of packer ball (3) compacts grout material to form effective seal. Packer ball is deflated (4) and moved to the next joint to be sealed.

Fig. 6.52. Operation of packer.

packer. It is unnecessary to disconnect the sleeve packer from the hoses since the packer is a self-sealing unit and there is no danger of the chemical sealing up in the packer if the unit is going to be used within three or four days. If the unit is to be idle for more than six days, the packer should be disconnected from its hoses and cleaned thoroughly.

It is not necessary to empty the hoses of sealing chemical unless the unit is to be idle for a long period of time, such as a winter time layover.

6.85 Specialized Applications

6.851 Roots

The use of root inhibiting chemicals with the sealing material is not recommended unless the roots are killed and removed prior to the sealing operation. The reason for this is that if you seal a joint with roots in the joint and then pack a chemical with a root inhibiting or killing agent into this area, it will kill the roots. The roots will then die and leave a hole when they decay and infiltration or exfiltration problems are back again. Roots should be killed, removed, and then the root inhibiting chemical added to the sealing chemical for use in the sealing operation.

6.852 Large Diameter Pipe Sealing

Special equipment is placed in the line which is designed to be lowered through a standard manhole and moved through the pipe to each joint to be sealed. The special sealing equipment does not damage, break or cause settlement, assuming the line is structurally sound.

The sealing equipment consists of two separate pumping systems capable of supplying a flow of sealing materials to form a new gasket or a seal on the infiltration or exfiltration point. The sealing material passes from the pumping system through hoses to the sealing device. This device (referred to as a packer) is a cylindrical case of a size less than the pipe size and consists of a steel ring, two inflatable end elements and one packing element.

Special care is used to prevent damage to the pipe from excessive amounts of sealing pressure. The packer is manually positioned over the area of the infiltration or exfiltration and the two inflatable elements are expanded using precisely controlled pressures (Fig. 6.53). These elements seal against the inside periphery of the pipe to form a void area at the point of infiltration or exfiltration which is now completely isolated from the remainder of the pipe lines.

Into this isolated area, the sealing chemical is pumped through the hose system (Fig. 6.54). The amount of sealing material will be determined by the size of the pipe and the condition of the joint. After the sealing material has been pumped into the isolated area, between the two elements, the packing element is then inflated, thus forcing the sealing material into the defective joint (Fig. 6.55).

The packer is held in the inflated position until the joint is cured.

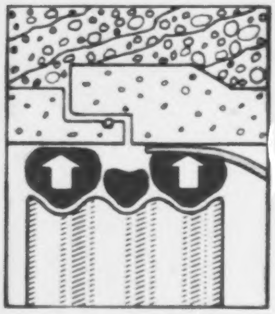


Fig. 6.53. Isolating joint.

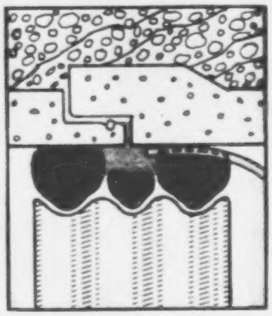


Fig. 6.54. Pumping sealing chemical.

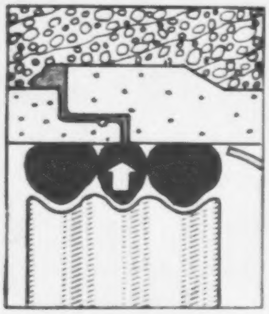


Fig. 6.55. Forcing sealing material into defective joint.

The large diameter sealing process requires a two-worker crew "down hole" to effectively run the operation (Fig. 6.56). Anytime a worker enters a large diameter pipe, the necessary safety precautions must be exercised (see Chapter 9, Section 9.5, Manholes and Other Confined Spaces).

Large diameter Polymeric Sealing is effectively used in pipes ranging in diameter from 30 to 120 inches with either bell and spigot or tongue-and-groove pipe.

Large diameter Pipe Sealing is a very specialized process and most work is done by contractors specializing in the process. Contact the equipment manufacturer for specific details.

A similar procedure can be used to control manhole infiltration (Fig. 6.57). A probe applicator injects the Sealant into leaky manhole walls.

6.86 Acknowledgements

All figures in this section courtesy of Cherne.

QUESTIONS

6.8D Why does the TV camera look at the packer?

6.8E Why should the TV camera be on the downstream side of the packer?

6.8F Why should only those joints that are not leaking be tested?

6.8G When can root inhibiting chemicals be used with a sealant?

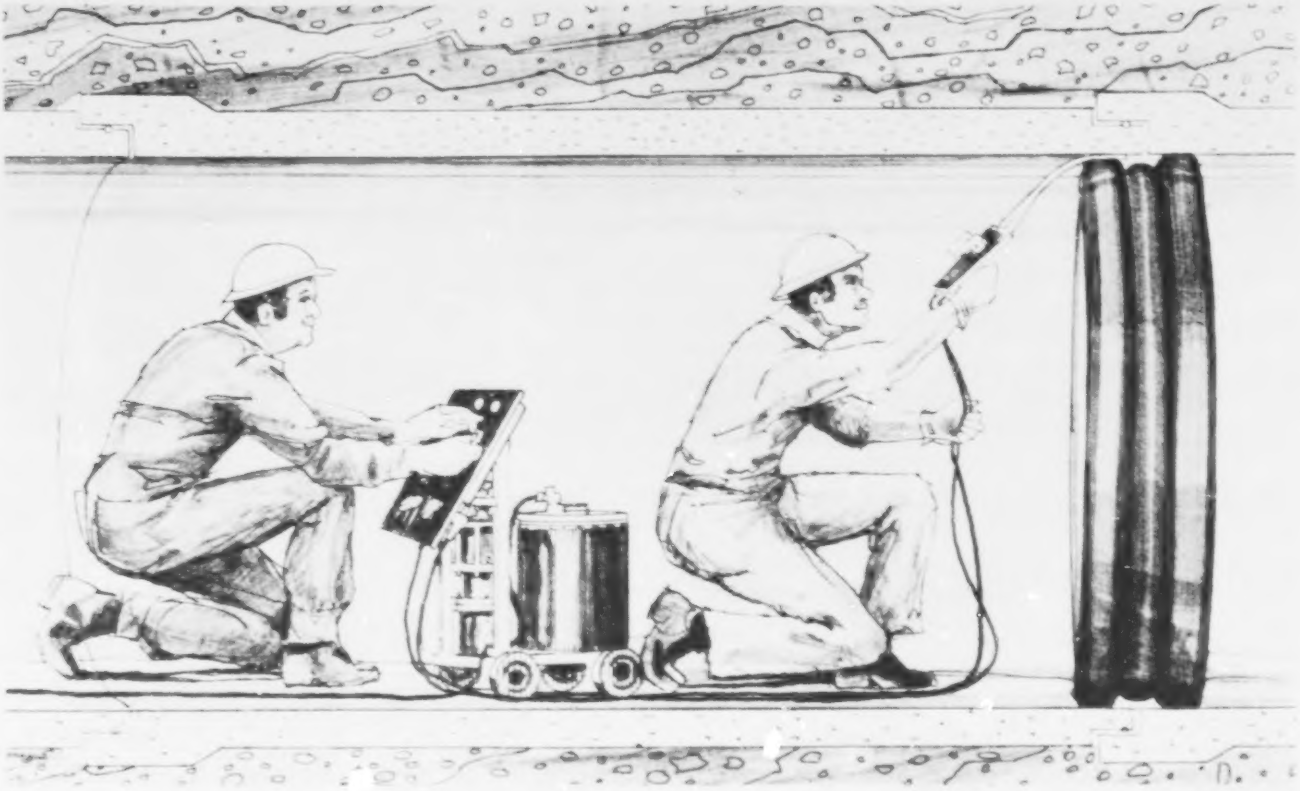


Fig. 6.58. Sealing large diameter pipe.

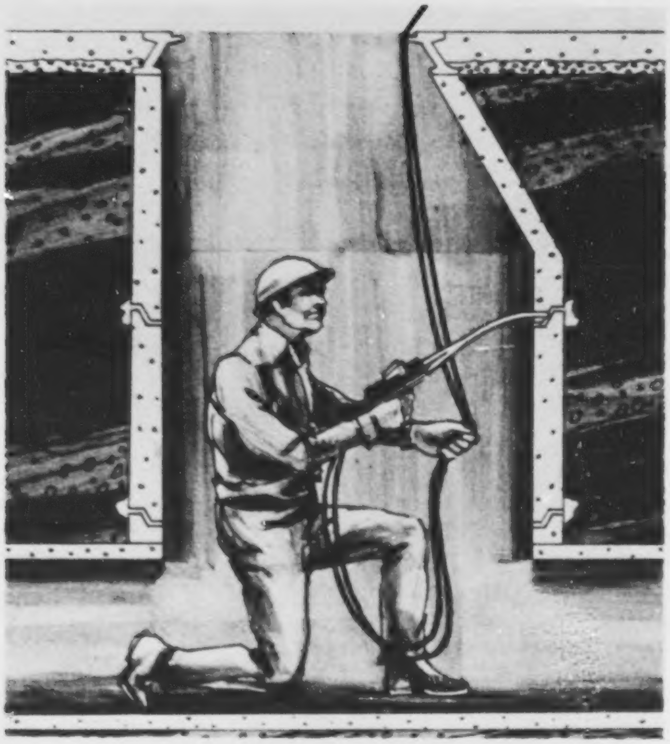


Fig. 6.57. Sealing manhole walls.

6.9 GUNITING[11] SEWERS

Sewers of brick, concrete, stone and combinations of these materials can deteriorate and require repair or rehabilitation. Gunite, because of its high density, is resistant to deterioration caused by wastewater and thus is a suitable lining material to prevent further deterioration and rehabilitate sewers thirty inches in diameter and larger.

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[11] Gunite. A mixture of sand and cement applied pneumatically that forms a high density, resistant concrete.

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Old brick sewers in danger of collapse can be restored by properly applying gunite. Restoration by using gunite strengthens the sewer and increases flow capacity. Figure 6.58 shows an old 8-foot diameter brick sewer which was lined with two inches of reinforced gunite.

Gunite also can be shot into defective or deteriorating joints. This procedure of applying gunite to leaking joints from the inside of a sewer can effectively seal these leaks.

END OF LESSON
3 OF 3 LESSONS
ON UNDERGROUND
REPAIR AND
NEW
CONSTRUCTION

DISCUSSION AND REVIEW QUESTIONS

Chapter 6. Underground Repair and New Construction

(Lesson 3 of 3 Lessons)

Write the answers to these questions in your notebook before continuing to the objective test on page 6-131. The problem numbering continues from Lesson 2.

16. What are the reasons for lining a sewer?

17. Why should the public be notified and what should the public be told before a sewer lining project is started?

18. How would you insert a liner in a main line?

19. How are sections of liner pipe joined together?

20. Why would a lateral be lined?

21. How is the space between the manhole and the liner sealed?

22. Why are sewers grouted or chemically sealed?

23. How would you seal a leaky joint in an 8-inch sewer?

24. How would you clean up after a sealing operation?

SUGGESTED ANSWERS

6.1A Underground repair and new construction are very hazardous because of the threat of cave-ins and dangerous gases.

6.1B Underground repairs are necessary to replace damaged pipe or to remove difficult obstructions.

6.1C Underground damages may be discovered by homeowners when the collection system fails, by emergency crews attempting to clear a stoppage, or by an inspector of a preventive maintenance crew.

6.1D Underground repair may be required if damage to pipe or stoppages are caused by roots, cracked pipe, protruding taps, improper taps and damage by the public, other utilities or construction activities.

6.1E A work request form notifies a foreman or crew leader and the crew of a repair job. The form specifies what is to be done and the job location. The foreman or crew leader and supervisor plan and schedule work on the basis of information on work request forms and other needs.

6.1F Before starting a repair job, a foreman should visit the job site and plan the job. Potential conflicts with traffic, utilities and other obstructions should be noted. Other utility agencies should locate their underground facilities. Property owners should be notified. Also a preconstruction and tail gate safety meeting should be held before starting the job.

6.2A Shoring requirements depend on depth of trench, width of trench, soil conditions, nearby activities and the laws and regulations.

6.2B Lack of shoring or shoring failure is the number one cause of cave-in deaths.

6.2C Shoring systems in trenches consist of some form of sheeting or liner, uprights held rigidly opposite each other against the trench walls by jacks or horizontal cross members (braces) and, if required, longitudinal members (stringers).

6.2D Uprights shall extend as near to the bottom of trench as permitted by the material being installed, but not more than 2 feet from the bottom.

6.2E Soil stability may be classified as hard compact, running or unstable.

6.2F All excavation work shall at all times be under the immediate supervision of someone with authority to modify the shoring system or work methods as necessary to provide adequate safety.

6.2G Spoils or excavated material must be placed two feet or more back from the edge of the trench. If the trench is over 5 feet deep, spoil must be placed more than 4 feet back from the edge of the trench.

6.2H All trenches deeper than 5 feet must be shored.

6.2I If shoring is not practical, the sides or walls of an excavation may be sloped.

6.2J Walkways must be provided for pedestrians to keep them out of the way and from being injured.

6.2K Different types of common shores include:

1. Hydraulic
2. Screw Jacks
3. Air
4. Solid Sheeting
5. Cylinder
6. Shield.

6.2L The main advantages of hydraulic shores are their ease of installation and they can be installed by one person.

6.2M The main advantages of screw jacks are that they are inexpensive to purchase and are practical for minor repairs in smaller excavations. A limitation is that they are time consuming to install.

6.2N Solid sheeting must be installed when excavation is in material that will not stand vertical and because of location, it is not practical to slope the trench.

6.2O Material is excavated in small cylinder shoring by hand using a shovel. In cylinders with a large enough diameter, material can be removed mechanically.

6.2P Cylinder shoring is used when the working area is small and only a small portion of the main line must be exposed.

6.2Q Shield shoring is used during excavation and installation of various types of sewers in areas and soil conditions that present a combination of problems.

6.2R The major concern during a shoring operation is the protection of the workers. Assume all trenches and excavations are unsafe.

6.3A Repair assignments must be made in writing in order to maintain records and provide a history of who made what repairs when, where and why.

6.3B Upon receipt of a work order request, examine existing records to determine if the problem has occurred in the past. During the preliminary field investigation, alert the homeowner and look for any unusual problems that may exist such as trees or shrubs that could get in the way.

6.3C Before a crew drives to a repair job, all safety equipment should be inspected and the truck should contain the proper equipment, materials and tools to do the job.

6.3D Upon arrival at the job site, verify that the address and map location are correct. Place traffic cones at front and rear of truck in accordance with local regulations. Notify property owner and discuss care of any plants or trees that may have to be moved.

6.3E Placing soil from an excavation on a canvas protects the grass and allows for easier shoveling of soil back into excavation.

6.3F When excavating to repair a sewer line, be careful not to damage or break other utility lines. Also use shoring if necessary to prevent cave-ins. Ventilation equipment should be available and used when necessary.

6.3G After a pipe is cut, carefully remove section so you don't get cut on sharp edges of pipe and be sure inside of pipe is clear before installing cleanout.

6.3H Use gravel or sand and crushed rock in the bottom of the trench for bedding of wye.

6.3I Before backfilling trench, inspect job, tighten all couplings or seal joints, and be sure there are no tools remaining in ditch.

6.3J A service line location card must be completed to provide a record of location of cleanout for future reference.

6.3K The crew leader should review job with foreman when it is completed. Any potential problem areas should be discussed so foreman can communicate with homeowner or supervisors.

6.4A Before a crew is assigned a main line repair job, the foreman makes a preliminary field investigation to identify potential problems and to plan the repair job. The foreman marks the repair area with paint and meets with representatives of utility agencies at the job site.

6.4B The foreman needs other utility agencies to indicate location and depth of their utilities at the job site.

6.4C Before the crew starts the job, the foreman and crew chief review a map of the job site, the proper procedures and safety precautions, and the necessary equipment, tools and materials.

6.4D Before leaving the yard for the job site, the crew should inspect all equipment (including safety) and determine that all the necessary equipment, tools and materials needed to do the job are loaded on the trucks.

6.4E When arriving on the job site, the crew should carefully park the trucks, prepare traffic control and contact homeowners and owners of parked vehicles. If parked vehicles are a potential problem, the job site can be barricaded and marked the night before or very early in the morning.

6.4F Before cutting the street, the crew should verify the location of the repair area by measuring the distances from the upstream and downstream manholes.

6.4G Unidentified utilities may be located by watching for changes in soil texture or other signs that could indicate the presence of cross trenches.

6.4H Usually spoils from an excavation are suitable for backfill because the material comes from an old backfill.

6.4I Keep the spoils pile at least four feet from edge of trench if the trench is over 5 feet deep and, if shallower, spoil must be at least 2 feet from edge of trench.

6.4J By use of an extension probe determine the elevation of the line being repaired.

6.4K The backhoe can dig to within six inches of the main line.

6.4L Lower equipment and material into the trench using a bucket and rope.

6.4M All loose dirt should be removed from under the main line to prevent a muddy mess and to provide room for gravel to form the bedding material for the pipe.

6.4N The backfill is compacted by jetting.

6.4O The job site is protected by barricades with flashers until the patching crew arrives.

6.5A Manhole lids should be raised when they are below ground level or they are paved over when a street is repaved. Below grade manholes are difficult to locate and may be subject to surface inflow.

6.5B Paved over manholes can be located using a metal detector.

6.5C To determine the height, the manhole lid should be raised, place a straight rod or 2 x 4 board across the cut around the manhole and measure the distance from ground level to the manhole lid.

6.5D Place the casting from the manhole a safe distance away where it won't slide back into the hole or cave in the side of the trench.

6.5E Clean the top of the grade ring or cone using a wire brush or scraper.

6.5F The worker placing and shaping the grout should wear rubber gloves to protect exposed skin.

6.5G If a fence was over a manhole whose lid was raised, replace the fence and cut a notch out of the bottom board so the lid can be removed. Notify property owners.

6.5H Manhole walls should be washed before inspection to clear the walls of material such as mud, grease, or other debris. Washing also helps clean out spiders, centipedes and other annoying pests.

6.5I Problems encountered at the bottom of manholes include no bottom, flat bottom,basin bottom, low incoming invert elevation to high outgoing invert elevation that causes a sump problem, improper channels, and disjointed pipe junctions.

6.5J To start repair of a manhole with no bottom,either plug off all incoming lines and pump wastewater to a downstream manhole, or bridge a channel or channels across the manhole bottom to allow flow to continue.

6.5K The base in the manhole should consist of cobble rock and crushed rock for the new concrete bottom.

6.5L Brush the concrete surface on the bottom of a manhole to prevent a slick surface.

6.5M Channels are formed by hand when using speed-crete.

6.5N Smooth channel surfaces can be obtained using speed-crete by wiping down the walls with a wet rag or wet sponge.

6.5O Speed-crete has a higher resistance to acids and sulfide than concrete because it consists of aluminum and plastics.

6.5P Channel corrections are made to correct flow problems and produce smooth flow through the manhole.

6.5Q Channel corrections are made by removing obstructions or poor channels with jack hammers and reshaping or providing new channels using speed-crete.

6.5R An inside drop line consists of a tee, pipe and 90-degree angle installed in a manhole to divert water from an incoming line to the main flow channel at the bottom of the manhole.

6.5S Inside drop lines are installed in manholes to stop splashing, odors, and difficult working conditions.

6.5T Inside drop lines are strapped to manhole walls.

6.5U Plastic class 125 pipe is used for inside drop lines.

6.7A Liners can be an effective method of repairing or reconditioning a sewer system by providing a new, smooth pipe to convey the wastewater. This new pipe does not leak (no infiltration or exfiltration) and prevents root intrusion.

6.7B A letter to home owners explaining a "slip lining" project should indicate

1. Why the project is necessary,
2. What is planned,
3. What is expected to be accomplished,
4. Costs.

The letter should state that the home owner may be temporarily inconvenienced during construction and also explain the benefits that will result from the completed project.

6.7C A sewer should be televised before "slip lining" to locate laterals, any mis-alignment and any other discrepancy which may need to be corrected before the actual lining takes place.

6.7D Equipment needed to weld polyethylene pipe together includes fusion joiner jigs, mobile carts, a butt fusion tool or squaring tool, heating faces for heating saddles, tapping or coring tools and accessories used for the adoption to the various size pipe that will be used and the pulling heads.

6.7E Three crews are recommended for a "slip lining" project.

1. Assemble liner.
2. Excavating crew digs pull hole at pre-determined location.
3. Pulls liner.

6.7F The liner should be marked at 50-foot intervals so, if the pipe hangs up in the line, the location can be found and the pipe dug up.

6.7G When "slip lining" laterals, dig holes where the lateral connects to the main line and where the lateral enters the house.

6.7H Cleanouts should be installed to provide an inspection point and a cleaning point.

6.7I The space between the liner and the manhole is sealed to prevent infiltration and/or exfiltration at the manhole.

6.8A Grouting or sealing can be considered as a possible means of repairing or rehabilitating sewers when the sewers are in an area that is unsuitable for excavation and is either infiltrating or exfiltrating through leaking joints, cracks or small holes. Sealing processes also are used on new construction of sewer lines where the contractor is unable to pass the line acceptance test.

6.8B The basic pieces of sealing equipment include the air compressor, chemical pump, water pump, control panel and sleeve packer.

6.8C The Polymeric Sealant has the following properties:

1. Resistance to most organic solvents, mild acids and alkali.

2. Returns to shape after repeated deformations.

3. Essentially non-toxic in cured form.

4. Does not become rigid or brittle when exposed to freeze-thaw or dry or low moisture conditions.

5. Noncorrosive and does not contain neurotoxic ingredients in either cured or uncured form.

6.8D The TV camera looks at the packer so the sealing operation can be observed.

6.8E The TV camera should be on the downstream side of the packer because the upstream water build up cuts valuable time from the operation and obscures much of the visual inspection of the process.

6.8F Leaky joints don't have to be tested because they have to be sealed anyway.

6.8G Root inhibiting chemicals can be used with a sealant only after the roots in the sewer and joints have been killed and removed.

OBJECTIVE TEST

CHAPTER 6. UNDERGROUND REPAIR AND NEW CONSTRUCTION

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

1. Angle of repose means angle of

    1. Slope of sewer.
    2. Slope of trench excavation.
    3. Slope of cut.
    4. Slope of unsupported loose soil.
    5. Slope of drainage ditch.

2. When excavating to repair a sewer, the following safety precautions must be considered -- protect the workers from:

    1. Cave-ins.
    2. Traffic.
    3. Injury.

    and also protect

    4. Public from injury.
    5. Public and private utilities, such as water, electricity and gas transmission lines.

3. Sewers can be damaged or blocked by

    1. Roots.
    2. Improper taps.
    3. Manholes between sewers.
    4. Kites.
    5. Underground construction damaging the sewer.

4. Before starting an underground sewer repair job, other companies with underground utilities in the area must be contacted to

    1. See if they have some excavating to do in the area too.
    2. Determine how long its been since they dug up the street.
    3. Have these companies mark the location of their utilities in the area of the repair job.
    4. Find out if their equipment can be borrowed.
    5. See if they want to help route traffic while you are doing the repair job.

GO TO NEXT PAGE

5. The need for shoring and shoring requirements depends on

    1. Depth of trench.
    2. Type of soil (clay, loam, sand).
    3. Soil conditions (compaction, moisture).
    4. Width of trench.
    5. Nearby activities that could cause vibrations.

6. Soil stability may be classified as

    1. Loose.
    2. Creeping.
    3. Running.
    4. Unstable.
    5. Hard compact.

7. Types of shores include

    1. Hydraulic Shores.
    2. Water Shores.
    3. Air Shores.
    4. Screw Jacks.
    5. Solid Sheeting.

8. After arriving at the job site to repair a sewer in an easement, the following tasks should be completed before the repair (excavation) is started

    1. Verify address and location of repair job.
    2. Place traffic cones on traffic side of truck at front and rear of truck.
    3. Conduct a tail gate safety and preconstruction meeting.
    4. Notify the home owner.
    5. Identify any plants or shrubs that have to be transplanted or replaced.

9. Main line repairs should be made when

    1. Grease blocks the line.
    2. The line continuously develops stoppages due to problems caused by the pipe or in the pipe.
    3. The pipe deteriorates.
    4. A new type of pipe is developed.
    5. A permanent stoppage occurs.

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10. When repairing a main line, the depth of the main line can be determined by

    1. Digging until the pipe is hit by the backhoe.
    2. Digging with a pick and shovel.
    3. Determining depth from plans, digging to within 18 inches, and then using a probe.
    4. Using a level.
    5. Opening a manhole and observing depth to top of pipe.

11. Types of manhole repairs may include

    1. Raising frame and cover to grade.
    2. Washing down sides and shelves.
    3. Killing insects and rodents.
    4. Correcting bottom channels.
    5. Installation of inside drops.

12. What items are inspected in a manhole to determine if repairs are needed in the manhole?

    1. Barrels for seepage.
    2. Cone for deterioration.
    3. Barrels for cracks.
    4. Bottom channel.
    5. Level of grease line.

13. Liners are installed in sewers to correct problems caused by

    1. Grease.
    2. Roots.
    3. Infiltration.
    4. Exfiltration.
    5. Protruding taps.

14. Before lining a sewer, the following tasks should be completed

    1. Make the liner slippery.
    2. Plan the operation on a step by step basis.
    3. Notify the public.
    4. Take photos of the yard around each house where landscape or grounds could be disturbed by the lining operation.
    5. Televise the sewer.

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15. Liners are inserted in laterals to

1. Control grease.
2. Complete the job.
3. Stop root intrusion.
4. Control infiltration.
5. Reduce exfiltration from system.

16. The public should be thanked when a "slip lining" project is completed because

1. It is good public relations.
2. The public was probably inconvenienced by the project.
3. Public support is always needed.
4. The public likes to get form letters in the mail.
5. The public relations department needs work.

17. Sealing or grouting may be used when

1. An area is unsuitable for excavation.
2. There is infiltration through joints.
3. There is exfiltration through cracks.
4. There is infiltration and exfiltration through small holes.
5. The salesman says it should be effective.

18. The Polymeric Sealant has the following properties:

1. Resistant to most organic solvents, mild acids and alkali.
2. Noncorrosive.
3. Stops grease build up.
4. Controls hydrogen sulfide.
5. Prevents stoppages.

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Review Questions

19. Traffic safety requires collection system workers to consider:

    1. Driving to job site.
    2. Parking vehicles at job site.
    3. Placing signs and barricades around job site.
    4. Routing traffic around job site.
    5. Routing pedestrians around job site.

20. Before entering a manhole, collection system workers must consider:

    1. Routing traffic.
    2. Testing the manhole atmosphere.
    3. Ventilating manhole.
    4. Using safety harness and lifeline.
    5. Lowering equipment and tools into manhole.

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CHAPTER 7

LIFT STATIONS

by

Manuel Munoz

and

John Brady

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OBJECTIVES

CHAPTER 7. LIFT STATIONS

After completion of Chapter 7 you should be able to do the following:

1. Determine locations of lift stations.
2. Describe requirements of a lift station.
3. Discuss components of a lift station.
4. Indicate advantages and disadvantages of the different types of controllers.
5. Review lift station prints and specifications.
6. Inspect a new lift station.
7. Keep lift station operating as intended.
8. Determine frequency of visits to a lift station.
9. Perform necessary lift station maintenance tasks.
10. Prepare record forms for a lift station, complete and file them.

LOCATION
PRINTS
SPECS
RECORD FILES
MAINTENANCE
VISITS

GLOSSARY

CAVITATION (CAV-i-TAY-shun) CAVITATION

The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.

COMMINUTOR (com-min-OO-ter) COMMINUTOR

A device used to reduce the size of the solid chunks in wastewater by shredding (comminuting). The shredding action can be visualized if you imagine many scissors cutting or hammering to shreds all of the large solids in the wastewater.

DISCHARGE HEAD DISCHARGE HEAD

The pressure (in feet or pounds per square inch (psi)) on the discharge side of a pump. The pressure can be measured from the center line of the pump to the hydraulic grade line of the water in the discharge pipe.

DRY PIT DRY PIT

See DRY WELL.

DRY WELL DRY WELL

A dry room or compartment in a lift station, near or below the water level, where the pumps are located.

DYNAMIC HEAD DYNAMIC HEAD

When a pump is operating, the vertical distance (in feet) from a point to the energy grade lines. Also see TOTAL DYNAMIC HEAD and STATIC HEAD.

ELECTROLYTE SOLUTION (e-LECK-tro-light) ELECTROLYTE SOLUTION

A special solution that is capable of conducting electricity.

ENERGY GRADE LINE (EGL) ENERGY GRADE LINE (EGL)

A line that represents the elevation of energy head (in feet) of water flowing in a pipe, conduit or channel. The line is drawn above the hydraulic grade line a distance equal to the velocity head of the water flowing at each section or point along the pipe or channel.

FORCE MAIN FORCE MAIN

A pipe that conveys wastewater under pressure from the discharge side of a pump to a point of gravity flow downstream.

HEAD HEAD

A term used to describe the height or energy of water above a point. A head of water may be measured in either height (feet) or pressure (pounds per square inch (psi)). Also see DISCHARGE HEAD, DYNAMIC HEAD, STATIC HEAD, SUCTION HEAD, SUCTION LIFT and VELOCITY HEAD.

HYDRAULIC GRADE LINE (HGL) HYDRAULIC GRADE LINE (HGL)

The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the hydraulic grade line is at the level water would rise to in a small tube connected to the pipe. To reduce the release of odors from sewers, the water surface should be kept as smooth as possible.

IMPELLER IMPELLER

A rotating set of vanes in a pump designed to pump or lift water.

LIFT STATION LIFT STATION

A wastewater pumping station that lifts the wastewater to a higher elevation when the continuance of the sewer at reasonable slopes would involve excessive depths of trench, or that raises wastewater from areas too low to drain into available sewers. These stations may be equipped with air operated ejectors or centrifugal pumps. Sometimes called a 'PUMP STATION'. The term 'PUMP STATION' is usually reserved for a similar type of facility that is discharging into a long 'FORCE MAIN', while a lift station has a discharge line or force main only up to the downstream gravity sewer. Throughout this manual when we refer to lift stations. we intend to include pump stations.

LUBRIFLUSHING LUBRIFLUSHING

Where bearings are grease lubricated, remove relief plug and apply proper lubricant to the bearing at the lubrication fitting. Run pump and expel excess lubricant.

PNEUMATIC EJECTOR (NEW-MAT-tik E-JECK-tor) PNEUMATIC EJECTOR

A device for raising wastewater, sludge or other liquid by alternately admitting it through an inward-swinging check valve into the bottom of an airtight pot and then discharging it through an outward-swinging check valve by admitting compressed air to the pot above the wastewater.

PUMP PIT PUMP PIT

A dry well, chamber or room below ground level in which a pump is located.

STATIC HEAD STATIC HEAD

When water is not moving, the vertical distance (in feet) from a point to the water surface. Also see DYNAMIC HEAD.

STILLING WELL STILLING WELL

A pipe, chamber, or compartment with a relatively small inlet or inlets connected to a main body of water, such as water in a wet well. The purpose of a stilling well is to dampen waves or surges while allowing the water level within the well to rise and fall with the major fluctuations of the main body of water. It is used with water measuring flow and depth devices to improve the accuracy of measurement.

SUCTION HEAD SUCTION HEAD

The pressure (in feet or pounds per square inch (psi)) on the suction side of a pump. The pressure can be measured from the center line of the pump up to the elevation of the hydraulic grade line on the suction side of the pump.

SUCTION LIFT SUCTION LIFT

The negative pressure (in feet or inches of mercury vacuum) on the suction side of a pump. The pressure can be measured from the center line of the pump down to the elevation of the hydraulic grade line on the suction side of the pump.

TOTAL DYNAMIC HEAD (TDH) TOTAL DYNAMIC HEAD (TDH)

When a pump is lifting or pumping water, the vertical distance (in feet) from the elevation of the energy grade line on the suction side of the pump to the elevation of the energy grade line on the discharge side of the pump.

VELOCITY HEAD VELOCITY HEAD

A vertical height (in feet) equal to the square of the velocity of flowing water divided by twice the acceleration due to gravity ($V^2/2g$).

VOLUTE (vol-LOOT) VOLUTE

The spiral-shaped casing surrounding a pump impeller that collects the water discharged by the impeller.

WET PIT WET PIT

See WET WELL.

WET WELL WET WELL

A compartment or room in which wastewater is collected, and to which the suction pipe of a pump may be connected. Also a submersible pump may be located in a wet well.

CHAPTER 7. LIFT STATIONS

(Lesson 1 of 5 Lessons)

7.1 PURPOSE OF LIFT STATIONS

Lift stations are used to lift or raise wastewater or storm water from a lower elevation to a higher elevation. Lifting of the wastewater is accomplished by centrifugal pumps or air operated ejectors. The term 'LIFT STATION' usually refers to a wastewater facility with a relatively short discharge line up to the downstream gravity sewer. A 'PUMP STATION' commonly is a similar type of facility that is discharging into a long 'FORCE MAIN'.[1] Throughout this manual when we refer to lift stations, we intend to include pump stations.

7.11 Location

Location and design of lift stations depend on economic factors that are analyzed by the design engineer. Lift stations are installed at low points in the collection system at the end of gravity sewers where the following conditions exist:

1. Excavation costs to maintain gravity flow and sufficient velocity become excessive,
2. Soil stability is unsuitable for trenching,
3. Ground water table is too high for installing deep sewers, and
4. Present wastewater flows are not sufficient to justify extension of large trunk sewers and a lift station offers an economical short-term solution.

Lift station pumps are designed to move the wastewater with a minimum of energy consumption. The pumps are selected to provide a flow as continuous or constant as possible to minimize surges of wastewater in the downstream sewer and the wastewater treatment plant. Consideration also must be given to installing pumps that require a minimum of maintenance.

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[1] Force Main. A pipe that conveys wastewater under pressure from the discharge side of a pump to a point of gravity flow downstream.

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Appearance of lift station buildings and grounds should blend in with the surrounding environment. Odors must be controlled and the noise must be kept to a minimum to prevent the lift station from being a nuisance to nearby neighbors.

Safety of the workers involved in operating and maintaining the lift station must be considered, as well as the safety of the public. If chemicals are added to the wastewater at the lift station, care must be exercised when storing, handling, and applying these chemicals.

Collection system workers should have easy access to the lift station during all types of weather conditions so the station can be properly operated and maintained at all times. Utilities required to operate the station must be readily available.

Reliability is the most important requirement of a lift station. Pumps or ejectors, controls, and the maintenance program must be designed to minimize the chances of failures to prevent the flooding of homes and streets.

QUESTIONS

7.1A How is wastewater raised or lifted in a lift or pump station?

7.1B What factors influence the location of lift stations?

7.1C What are the two major safety items that must be considered around a lift station?

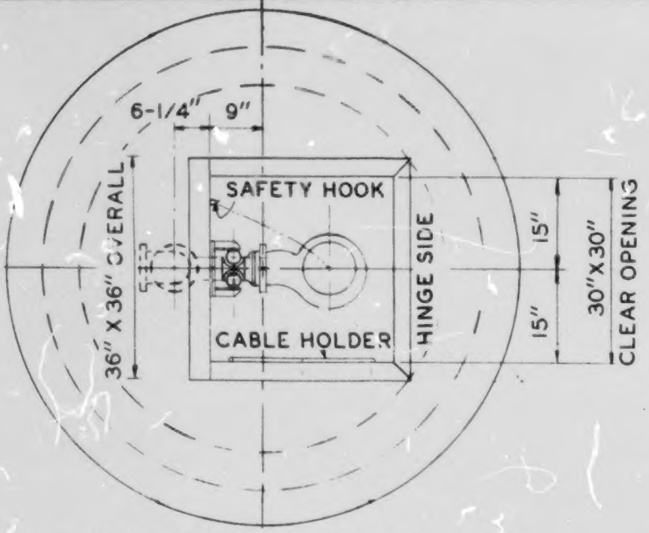
7.12 Types of Lift Stations

Wastewater lift stations may be constructed in various sizes and shapes depending upon the volume of wastewater or storm water to be handled, the elevation water must be lifted, and the distance water must be pumped before the water returns to flowing in a gravity system. The lift station may range from a standard manhole equipped with a submersible or other wet well type pump, to a factory prefabricated package station, or to an elaborately designed and constructed station capable of pumping large volumes of wastewater. When larger stations are constructed and require a continuous operational staff, they are often referred to as pumping plants.

Stations may be classified as wet well or dry well installations, depending on the locations of the pumping units.

7.121 Manhole Used as Wet Well Station (Figure 7.1)

Manholes have been used as lift stations with submersible pumps to serve small isolated areas of ten to fifty homes for short, interim periods until major trunk or intercepting sewers may be extended to serve the area. The lift station shown in Figure 7.1 has guide bars made of two-inch pipe. These two bars allow the pump to be removed from the top of the manhole by pulling the pump up the guide bars. The weight of the pump holds it in place and there are no bolts to remove.


6-1/4"
9"
SAFETY HOOK
36" X 36" OVERALL
HINGE SIDE
CABLE HOLDER
15"
15"
30"X30"
CLEAR OPENING

PLAN VIEW GRADE ELEVATION

NOTE:
CONFIGURATION AND DIMENSIONS SHOWN ARE SUGGESTED MINIMUM REQUIREMENTS ONLY. ALL DETAILS, INCLUDING SIZING OF PIT, TYPE, SIZE, LOCATION AND ARRANGEMENT OF VALVES AND PIPING, ETC. ARE TO BE SPECIFIED BY THE CONSULTING ENGINEER AND ARE SUBJECT TO HIS APPROVAL

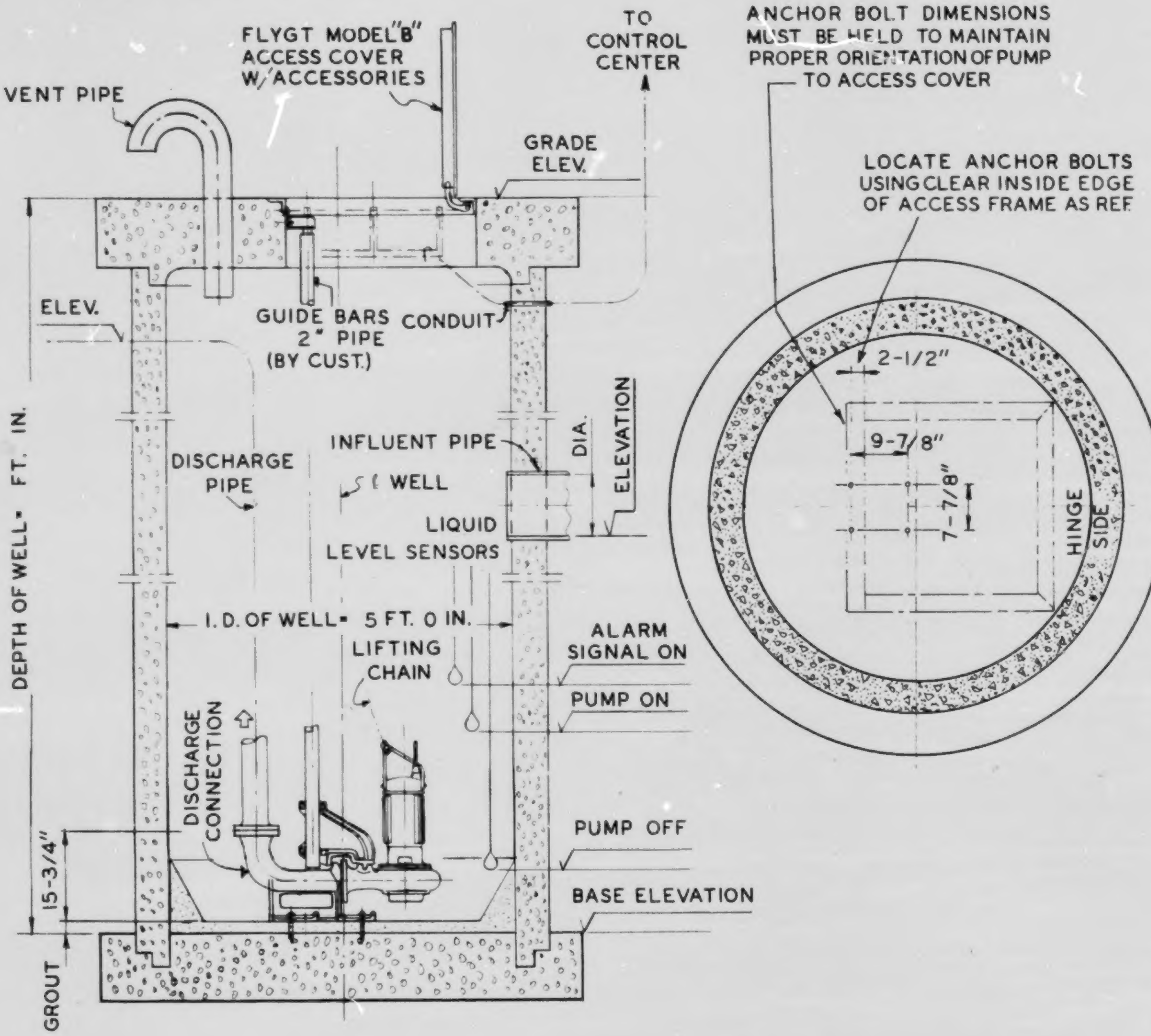

FLYGT MODEL "B" ACCESS COVER W/ ACCESSORIES
TO CONTROL CENTER
ANCHOR BOLT DIMENSIONS MUST BE HELD TO MAINTAIN PROPER ORIENTATION OF PUMP TO ACCESS COVER
VENT PIPE
GRADE ELEV.
LOCATE ANCHOR BOLTS USING CLEAR INSIDE EDGE OF ACCESS FRAME AS REF
ELEV.
GUIDE BARS 2" PIPE (BY CUST.)
CONDUIT
2-1/2"
DEPTH OF WELL - FT. IN.
DISCHARGE PIPE
INFLUENT PIPE
℄ WELL
DIA.
ELEVATION
9-7/8"
7-7/8"
HINGE SIDE
LIQUID LEVEL SENSORS
I. D. OF WELL - 5 FT. 0 IN.
LIFTING CHAIN
ALARM SIGNAL ON
PUMP ON
DISCHARGE CONNECTION
15-3/4"
PUMP OFF
BASE ELEVATION
GROUT

Fig. 7.1. Submersible pump and water in wet well
(Courtesy of Flygt)

7.122 Wet Well Station

Wet well stations are usually confined to smaller installations that do not exceed 2500 GPM pumping capacity and the pumping unit is submerged in the wastewater. Pumps may be submersible motor driven or the pumps are located at the bottom of the well with a shaft connecting to a motor above the high water line. Wet well installations have limited access to the pumping equipment. If anything goes wrong, they can be difficult to repair.

7.123 Dry Well Station

Dry well stations are the most common lift stations built today because pumping units are isolated from the water being pumped (Figures 7.2 and 7.3). This feature provides a cleaner and safer environment for operation and maintenance workers. A standard manhole is often used as a wet well in smaller lift stations and also in factory assembled package lift stations using a centrifugal pump or a pneumatic ejector[2] (Figure 7.4).

QUESTIONS

7.1D What type of pump is often installed in a wet well?

7.1E What is a limitation of a pump installed in a wet well?

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[2] Pneumatic Ejector (NEW-MAT-tik E-JECT-tor). A device for raising wastewater, sludge or other liquid by alternately admitting it through an inward-swinging check valve into the bottom of an airtight pot and then discharging it through an outward-swinging check valve by admitting compressed air to the pot above the wastewater.

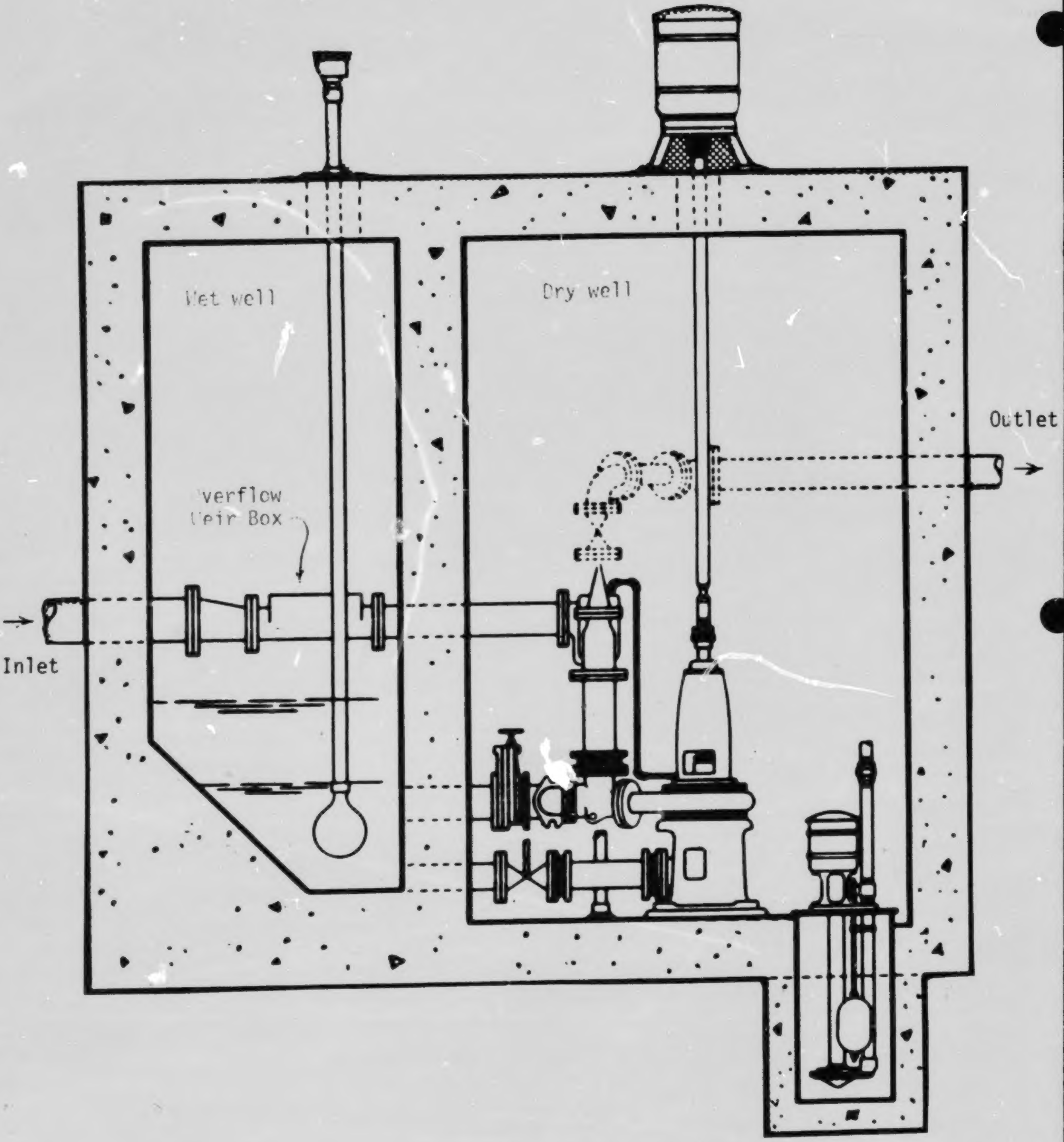
Wet well
Dry well
Outlet
Overflow
Weir Box
Inlet

Fig. 7.2. Pump in dry pit. Motor on top.
(Courtesy of Chicago Pump)

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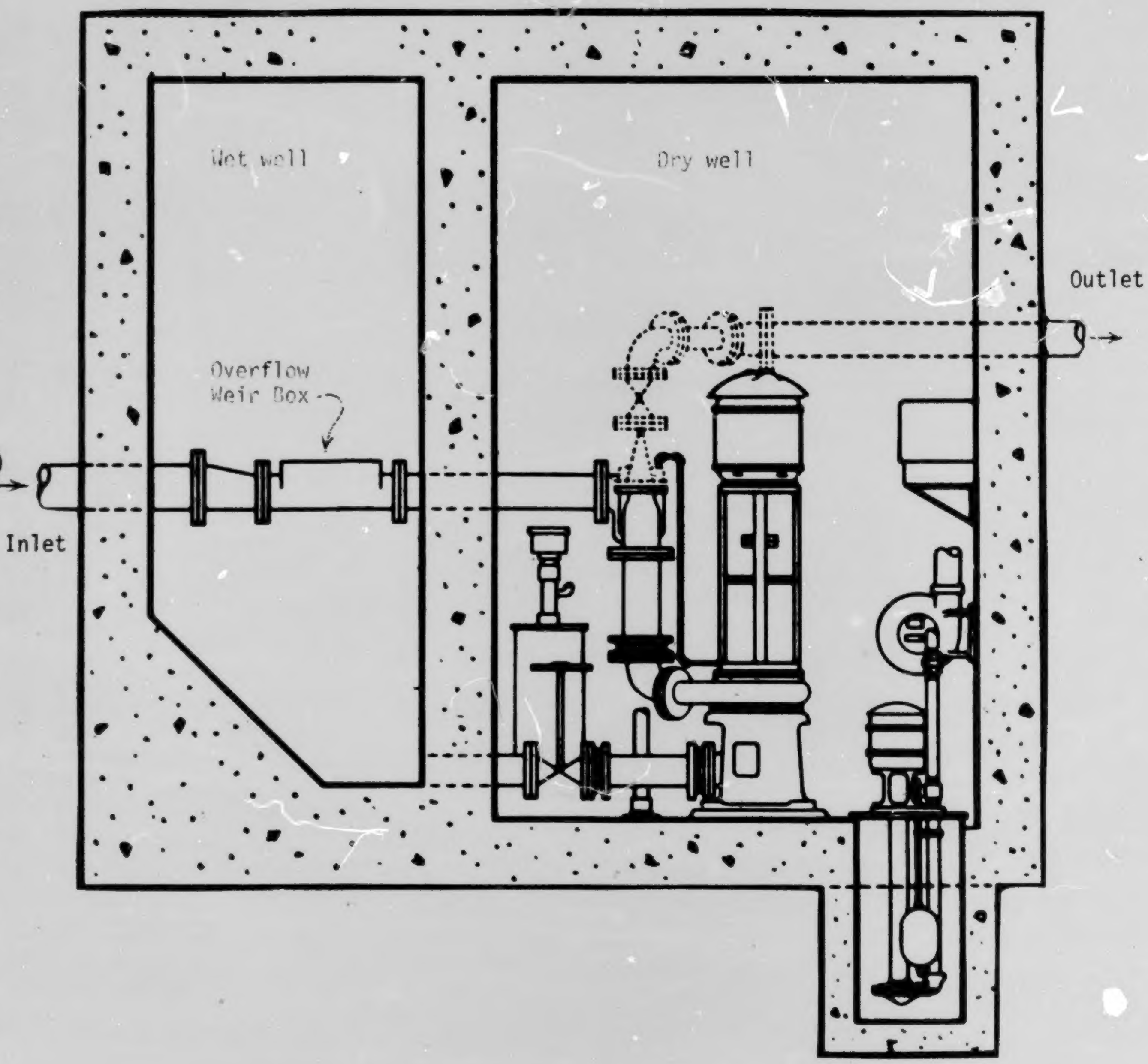
Wet well
Dry well
Outlet
Overflow
Weir Box
Inlet

Fig. 7.3. Pump intake in wet pit. Pump motor and control system in dry pit.

(Courtesy of Chicago Pump)

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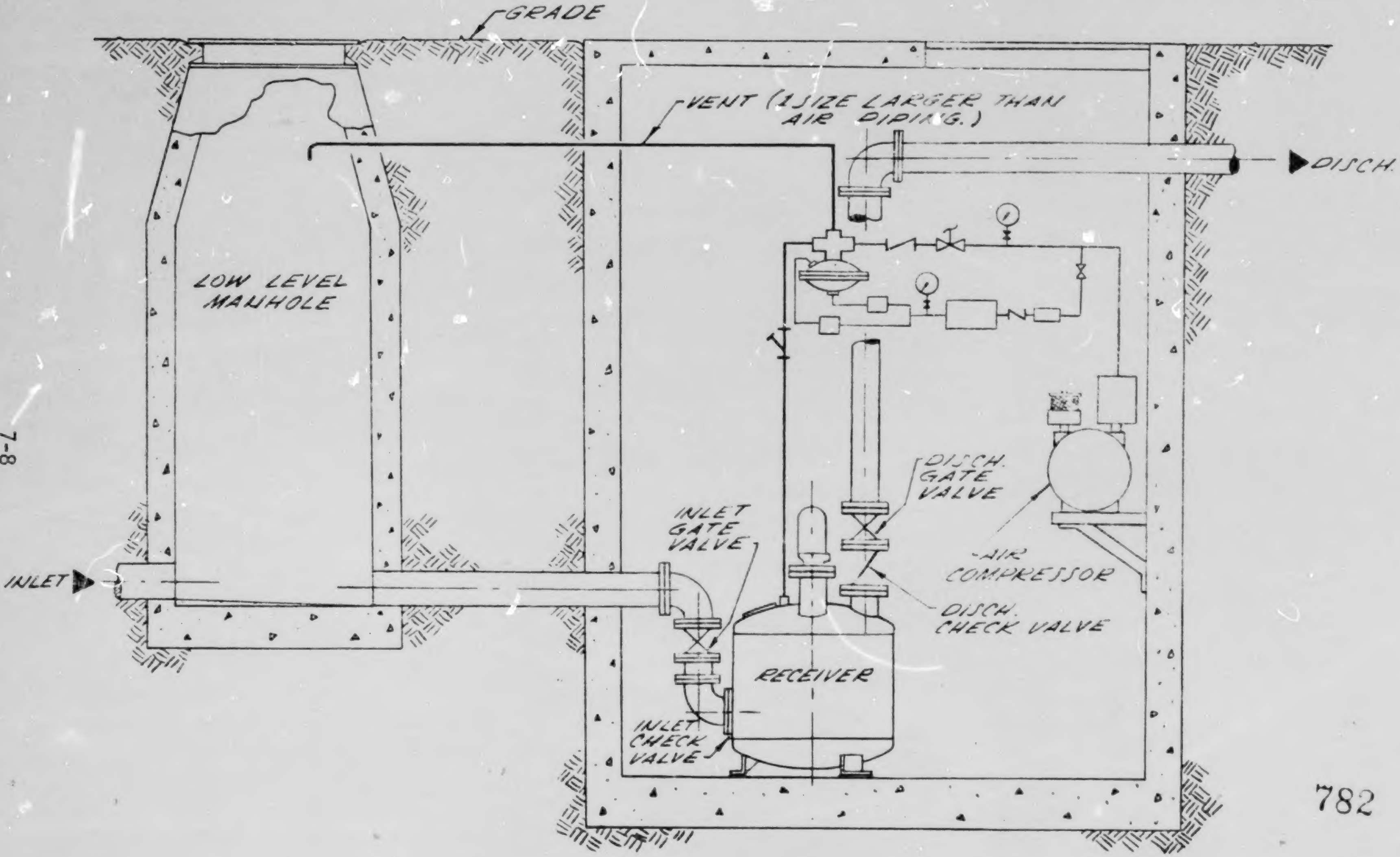
GRADE
VENT (1 SIZE LARGER THAN AIR PIPING.)
DISCH.
LOW LEVEL MANHOLE
INLET
INLET GATE VALVE
DISCH. GATE VALVE
AIR COMPRESSOR
DISCH. CHECK VALVE
RECEIVER
INLET CHECK VALVE

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781

Fig. 7.4. Manhole wet well and pneumatic ejector dry well station
(Courtesy of James Equipment and Manufacturing Company)

7.13 Lift Station Requirements

The most desirable operation of a lift station would be the situation where all the flow and solids that discharge into the wet well from the gravity sewer are lifted to the higher elevation and continue to the wastewater treatment plant without delay. This would occur with the highest use of equipment and energy efficiency possible. Also operational and maintenance problems would be minimized.

Some lift stations almost meet these ideal requirements, but there are many more that are unable to meet these requirements. Usually a lift station is designed to handle expected peak flows. Often this means that long detention or holding times occur in wet wells during low flow periods. Provisions for wet well aeration during low flow periods could help keep the detained wastewater fresh.

ECONOMIC
FACTORS

The most critical component of a lift station is the pumping unit; but pipes, valves, controls and power supply also are essential. All of these items must be "go" or the lift station will fail.

1. Flow

Most pump capacities are rated in GPM (gallons per minute). The design engineer must carefully estimate flows under operating conditions to select the proper pump or pumps for the lift station. Important operating conditions include:

Flow, Q_1 = Average daily dry weather flow.

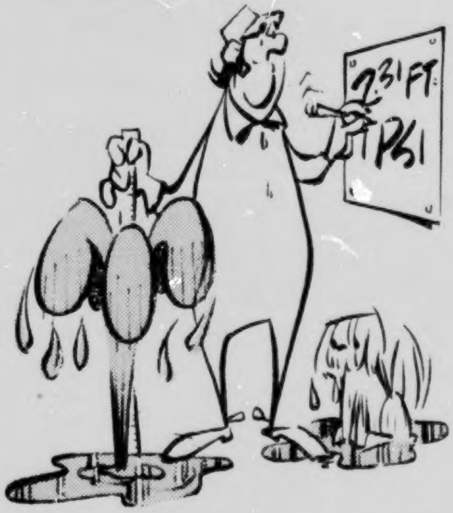
Flow, Q_2 = Seasonal dry weather flow (to handle industrial flows that produce high flows for 1 to 3 month periods such as canneries).

Flow, Q_3 = Peak wet weather flow (based upon a one-in-ten-year occurrence or some other severe storm frequency that produces conditions where inflow/infiltration may enter the collection system, especially important in combined wastewater and storm water collection systems.

Under certain circumstances, Q_2 and Q_3 may range from 1.5 to 10.0 times or more above Q_1. These high flows present greater problems in smaller lift stations than in the larger stations with multiple pumping units. All but the smallest lift stations should have sufficient pump capacity to handle peak flows. During usual or average flow conditions, the pumps that handle peak flows can serve as backup units during periods when the other pumps are shut down for maintenance and repairs.

2. Head

The term head refers to pressure head (pounds per square inch or psi) or elevation head (feet). Head is a vertical distance and is measured as the difference in elevation between two points. Head may be expressed in feet or psi.[3] Important head terms that should be known when pumps are selected include suction head, discharge head, total static head, and total dynamic head.



Suction heads may be positive or negative (suction lift), depending on whether the water level in the wet well is above (positive) or below (negative) the center line of the pump impeller. Discharge heads are measured on the discharge side of a pump from the center line of the pump to an

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[3] A column of water 2.31 feet high creates a pressure of 1 pound per square inch (psi) at the bottom of the column. Therefore

1 psi = 2.31 ft

and 1 ft = 0.433 psi

elevation on the discharge side. Static heads are shown on Figure 7.5 and dynamic heads on Figure 7.6. Static heads are measured when the pump is not operating and are the differences in elevation (in feet) between the surface of the water on the suction side of the pump and the surface of the water on the discharge side of the pump. Dynamic heads are measured when the pump is operating and depend on the velocity of water in the pump suction and discharge pipes. Dynamic heads are greater than static heads because they include the static heads plus the friction losses in the suction and discharge pipes. The energy required to start a pump is greater than the total dynamic head (TDH) during normal operating conditions because additional energy is required to start the motor and the pump and to start the water flowing through the pipes, the check valves, and the pump.

Friction losses result from pipe friction and the friction losses due to the water flowing through pipe fittings such as valves, reducers and elbows. The greater the velocity of flow in pipes, the greater the friction losses. Suction pipes are often larger in diameter than discharge pipes to reduce friction losses in the suction pipe and thus also to reduce cavitation[4] problems. However, cavitation problems are more likely to be caused by excessive tip speed of the impeller, air leaks on the suction side of the pump, and restrictions in the suction line. Friction losses may be calculated from tables in pump and pipe handbooks by knowing the flow (in GPM) and the diameter, type, and length of pipe and also the size and type of valves and fittings. See Appendix M.88, Friction or Energy Losses.

Design engineers try to minimize friction losses by careful layout of pipes, selection of pipe size (diameter) and length, and the number of valves and fittings. Consideration must be given to friction losses at expected flows and suction conditions when determining desired pump characteristics and selecting a pump. If the lift station piping and pumps are not properly designed, problems can develop from vibrations, cavitation, and insufficient pumping capacity, thus requiring excessive maintenance.

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[4] Cavitation (CAV-i-TAY-shun). The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.

NOTE: This figure illustrates a pump with a suction lift. Pumps should have a suction head which means the wet well water level should be higher than the pump impeller. This pump will have difficulty starting unless it is a self-priming pump because the water level in the wet well is below the pump. Also, if air gets into the suction line, the only way it can get out is through the pump.

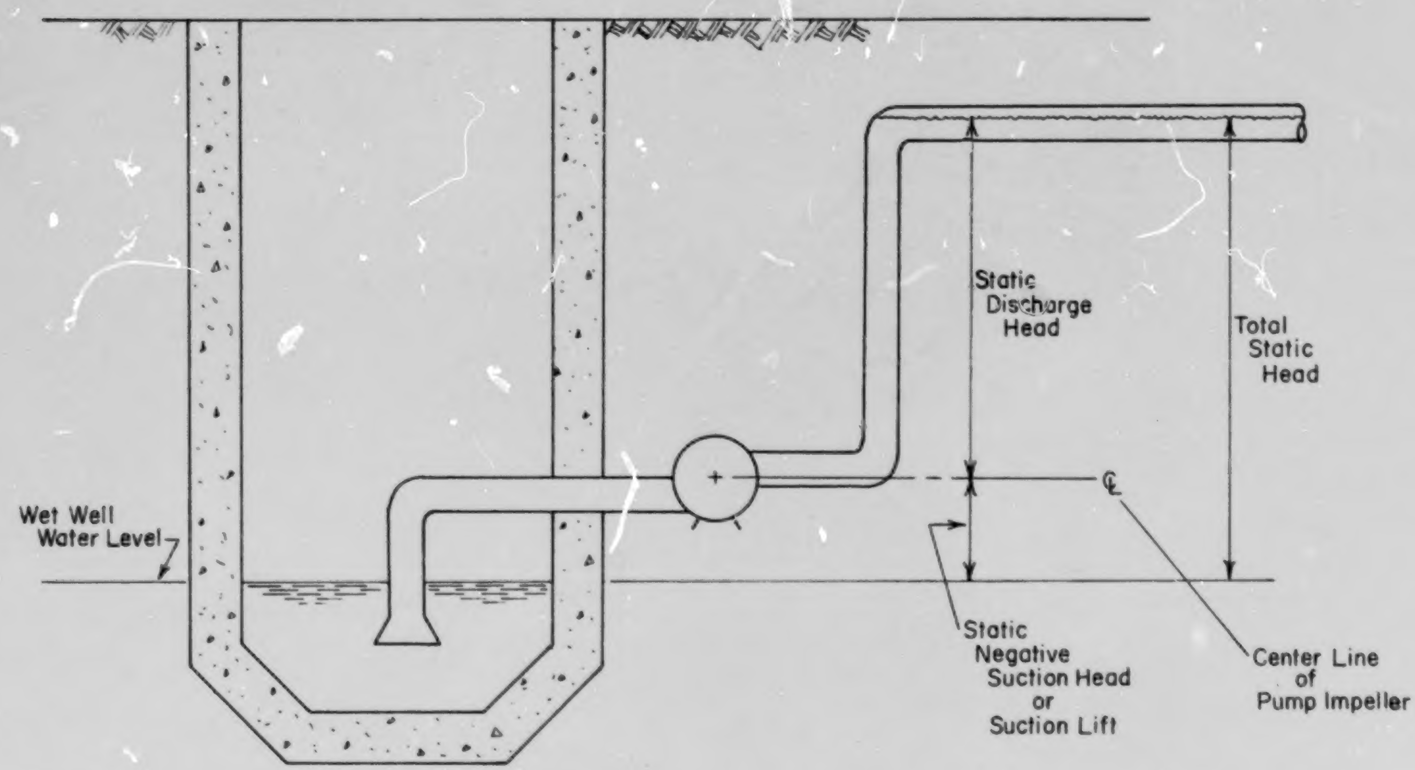
Static Discharge Head
Total Static Head
Wet Well Water Level
Static Negative Suction Head or Suction Lift
Center Line of Pump Impeller
℄

Fig. 7.5. Static heads (pump is not operating).

NOTE: This figure illustrates a pump with a suction lift. Pumps should have a suction head which means the wet well water level should be higher than the pump impeller. This pump will have difficulty starting unless it is a self-priming pump because the water level in the wet well is below the pump. Also, if air gets into the suction line, the only way it can get out is through the pump.

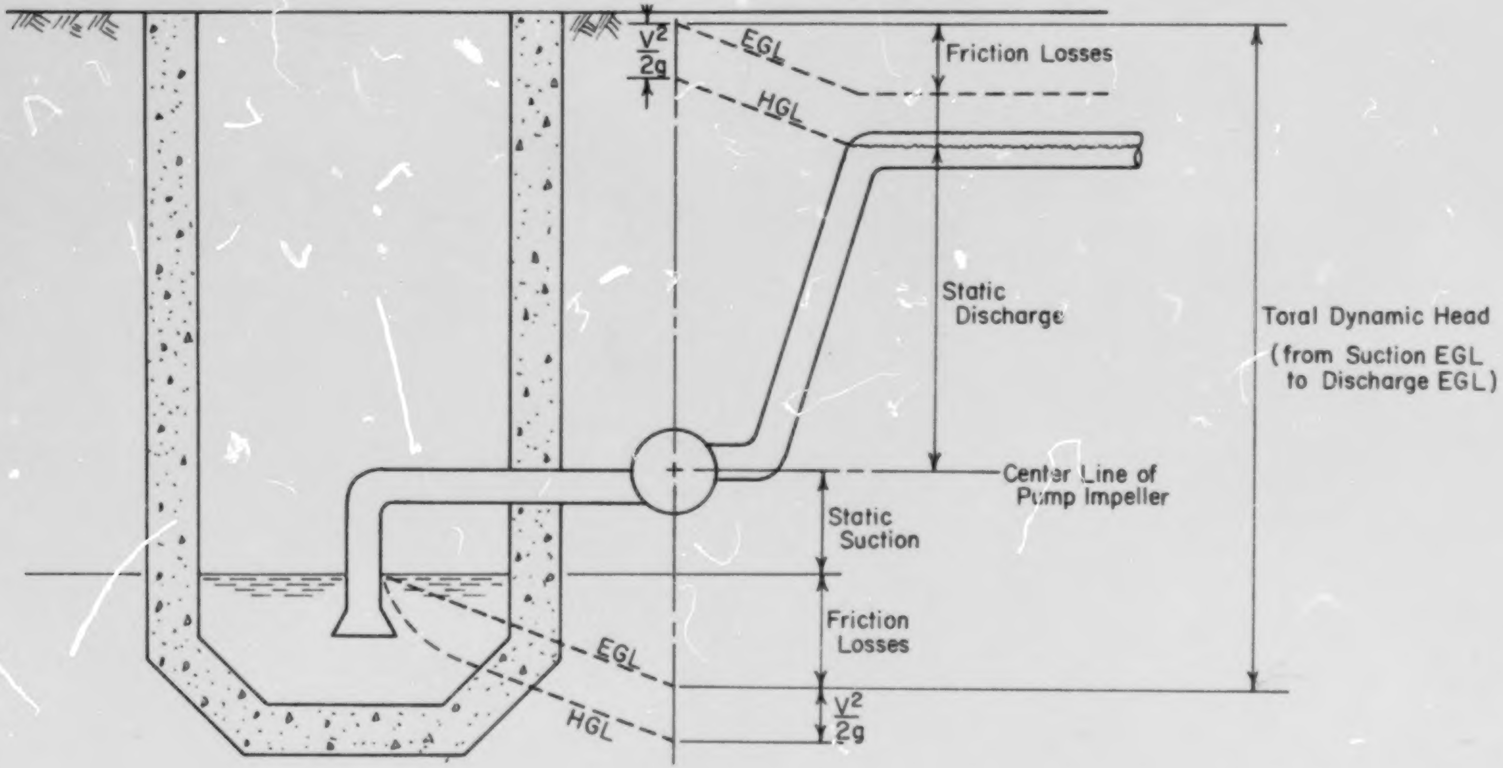
$\frac{V^2}{2g}$
EGL
HGL
Friction Losses
Static Discharge
Toral Dynamic Head
(from Suction EGL to Discharge EGL)
Center Line of Pump Impeller
Static Suction
Friction Losses
EGL
HGL
$\frac{V^2}{2g}$

Fig. 7.6. Dynamic heads (pump is operating).

EGL- Energy Grade Line
HGL- Hydraulic Grade Line
$\frac{V^2}{2g}$ - Velocity Head

QUESTIONS

7.1F What is the most desirable operational situation for a wet well?

7.1G What is the difference between static and dynamic head?

7.1H Friction losses are caused by what factors in a lift station?

END OF LESSON 1 OF 5
ON
LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 7. LIFT STATIONS

(Lesson 1 of 5 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. What is the purpose of a lift station?
2. Where are lift stations located?
3. What are the requirements for a lift station?
4. Why does a pump require more energy (draw more power) to start, than during normal operating conditions?

CHAPTER 7. LIFT STATIONS

(Lesson 2 of 5 Lessons)

7.2 COMPONENTS OF A LIFT STATION

7.21 Wet Wells

The size of the wet well is important to the pumping system operation. If the pumping system is an on-off operation, the wet well must be of sufficient size to contain and store wastewater so that the lead pump is not called to start more than ten to twelve times per hour. Frequent pump motor starts cause excessive wear on control circuit relays and motors, motor overheating, and also consumption of more electrical energy than that required by a pump that is started and allowed to run for a longer period of time. However, a wet well that is too large has the disadvantage of storing the wastewater for too long. A lengthy storage time permits solids to settle out and creates the opportunity for the wastewater to turn septic and produce excessive hydrogen sulfide and odors. Aeration of wastewater in the wet well will help keep solids suspended and the wastewater fresh.

Lift stations with multiple variable speed pumping units may have smaller wet wells because the pump starts operation on signals from devices (controls). These devices measure the wet well water level and regulate pump speed in response to the wet well water level or flow entering the wet well. This procedure keeps the pump operating for long periods of time or almost continuously. Variable speed pumping equipment's main advantage is that it comes close to meeting the desired lift station function of keeping the wastewater moving through the collection system without delay.

Wet well design must consider the location of the pump suction lines regarding submergence in order to eliminate the use of foot valves, to prevent cavitation due to low wet well levels, and to reduce vortexing action (formation of whirlpools) caused by water flowing into the wet well or the entrance to the pump suction. Where the wet well walls meet the bottom of the sump, fillets (material placed along the edge to provide a smooth, rounded surface) are installed to convey solids to the pump suction in order to remove the solids from the sump. The wet well should be covered, but provided with a vent and also an access hatch for cleaning and maintenance work and to allow full visual observation of the wet well from the top. Provisions should be made for ventilation to improve accessibility when needed.

QUESTIONS

7.2A Why should the pumps in a lift station not start and stop frequently?

7.2B What problems develop in a wet well that is too large?

7.2C What is the main advantage of variable speed pumping equipment?

7.22 Bar Racks

Installation of bar racks or screening devices in the wet well used to be a common practice, especially on the older combined wastewater and storm water collection systems due to the debris entering the system from the surface runoff drains containing leaves, sticks, cans, and trash. In collection systems for only domestic and industrial wastewaters, bar racks or screens have been eliminated at the lift station because most pumping units are equipped with open impellers[5] or closed two-port impellers sized to pass solids up to the size of a 2.5-inch diameter sphere. This is the largest size sphere which may pass through most home lavatory and disposal systems.

Bar racks are installed to prevent any large debris from entering and plugging or damaging a pump. In areas where vandals remove manhole covers and throw junk into sewers, bar racks may be helpful. When bar racks are used, they should be cleaned frequently so there is no substantial restriction of wastewater flow to the pumps. The cleaning of bar racks is accomplished with forks, screen baskets, or any type of tool capable of picking up the debris and removing it from the bar racks. A limitation of bar racks is the fact that screenings cause odors and attract flies.

Screenings are usually removed from the station in buckets and transported to a disposal site. Agencies that have removed bar screens from lift stations which pump sanitary wastewater have found the pump impellers occasionally become plugged with rags (two to three times a year). However, this problem is preferred to the necessity of visiting a station one or two times a day to clean a screen and struggle with hauling the screenings to a disposal site. Many pumps are designed to "chew" the rags into a size acceptable to be pumped.

In larger lift stations, some agencies are installing comminutors[6] and barminuters to shred rags and debris ahead of wet wells and pumps. A by-pass channel with a rack is needed for use when the comminutor be being repaired.

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[5] Impeller. A rotating set of vanes in a pump designed to pump or lift water.

[6] Comminutor (com-min-OO-ter). A device used to reduce the size of the solid chunks in wastewater by shredding (comminuting). The shredding action can be visualized if you imagine many scissors cutting or hammering to shreds all of the large solids in the wastewater. Barminuter (bar-min-OO-ter). A device similar to a comminuter.

7.23 Dry Wells

A dry well is that portion of the lift station which is isolated from the wastewater and used to house the necessary equipment for the lift station to function. The structure commonly has two or more floor levels. The lower floor usually contains the pumping units, isolation valves, discharge manifold (pipes), and a sump pump to remove excess water such as seal water leakage and clean up water.

Electrical control boards, motors, ventilation equipment, necessary station controllers and auxiliary equipment are housed on the upper floor. This provides protection to station equipment in case of a broken valve or fitting or a leak that would permit wastewater to flow from the wet well or force main into the dry well side of the station. Flooding of the lower level could occur, but the electrical systems, motors and expensive control equipment would be protected from water damage and would allow the station to be put back into service very quickly.

7.24 Electrical

Electrical power is provided by the utility company to the power pole transformer and then down the power line into the station at the electrical meter. Electrical systems start after the meter and feed the station from the main circuit breaker. The main circuit breaker can feed a single pump or go into a motor control center that distributes power to more than one pump and its control units and the station electrical equipment. Function of the main circuit breaker is to provide a device that produces a complete disconnect of the station from the power company source.

7.25 Motor Control Center

The motor control center, or main panel as it is sometimes called, houses the controls for all motors and electrical equipment operated within the station. These controls include a starter, fuses, heater strips and all the coils and relays necessary for any particular pump motor to operate.

7.26 Motors (See Chapter 8, Section 8.2, Electrical Equipment Maintenance)

Motors can have different voltages, horsepowers and ampere readings. Also, they will be rated at 60 cycles and single phase or three phase. Voltage ratings depend on the local power source and may be 208, 220, 240, 440, 460, 480 volts or higher for very large stations, 60 cycles, and three phase. Occasionally in a very small lift station a single-phase motor is used.

Submersible pump motors are an integral part of the pump and are encased in the pumping unit. When a seal fails on a submersible pump, the wastewater penetrates the motor compartment and burns or shorts out the motor. If a maintenance worker resets the unit and it operates properly for a short period of time with no overload, the worker can assume that a seal failure was not the reason for the shut off, but that the pump had overloaded the motor. Determine the load on the motor and check for proper voltage. Also look for plugged lines and be sure the wet well and pump are clear of rags, mud and debris that could cause a temporary overload.

QUESTIONS

7.2D Why have bar racks been eliminated or not installed in lift stations pumping only domestic and industrial wastewater?

7.2E What is the purpose of a sump pump in a dry well?

7.2F What happens when a seal fails on a submersible pump?

7.27 Controls

Controls to start, stop or change pumping rates in a lift station are used to tell the pumps when to operate based on the level of the wastewater to be pumped from the wet well. Primary controls such as floats, bubblers or pressure sensitive devices measure the level of water in a wet well. Secondary controls convert the measurement from the primary controls into a signal for a pump to start, stop, or change speed. These secondary controls convert a sensing signal into a mechanical or electrical signal which, in turn, actuates low voltage motor relays to start or stop motors or milliamp signals to change ranges on variable speed equipment.

7.271 Float Controllers

Float controllers are one of the oldest methods used to start and to stop pumps or to indicate the level of water surface in the wet well. The float may be a four to eight-inch diameter ball manufactured from copper or stainless steel, or it may be a flat plate of six to twelve inches in diameter and several inches thick manufactured from copper, stainless steel, or a ceramic material, or it may be a cylinder of six to ten inches in diameter and six to ten inches in depth and made of glass, stainless steel, or a ceramic material. In some instances old brown jugs were used for floats. The jugs were partially filled with sand or lead shot to provide stability and to counteract a portion of the float buoyancy.

All of these devices float on the water surface. When the wet well fills and the water surface rises, the float rises; and as the wet well is pumped down, the float drops with the water surface. The float must be physically attached by steel rods, steel tapes, cables, or ropes to transmit the rise and fall of the float to a recording or signaling device.

A. Rod attached floats (Figure 7.7)

Ball floats are usually attached to 1/4 or 3/8-inch steel rods. The rod is attached to the top of the ball float and extends up to or through the cover of the wet well and passes through the eye of an actuator arm that is connected to a micro switch. The float rod is equipped with brass stops on both sides of the micro switch arm. When the wet well fills, the bottom stop on the float rod pushes the micro switch arm up and starts the pump. When the wet well is pumped down, the float drops and the rod travels downward. When the top stop on the float rod pushes the micro switch arm down, it turns the pump off. The wet well rise and fall levels are selected or changed by moving the rod's stops to new positions on the float rod.

Lowering the bottom stop on the float rod permits a higher wet well water level by starting the pump later. Raising the bottom stop will lower the wet well level at which pumping is started. Once the top stop on the float rod is positioned, it should not be changed because it is set to turn the pump off before it loses suction. If a pump loses it's suction and is allowed to operate, the pump could be seriously damaged.

The most common application of ball type float controllers is on sump pumps and on small wet well type lift stations employing only one pump.

B. Steel tape, cable, or rope attached to floats (Figure 7.8)

This type of float is a little more complicated than the rod-attached float. Generally this type of float requires a stilling well for the float to prevent excessive movement of the float. Too much movement of the float will produce incorrect readings. A stilling well is usually a section of pipe ten to twelve inches in diameter which extends several feet above and below the normal wet well operating water level. Usually the stilling well stands vertically in a corner or against a wall of the wet well. The stilling well is open at the bottom or is provided with a smaller inlet pipe of 2.5 to 4 inches in diameter near the bottom to permit water in the stilling well to follow the rise or fall of the water in the wet well.

The float is housed inside the stilling well and is provided one to two inches of free clearance to permit the float to travel up and down the stilling well. At the top of the float is attached the steel tape, cable, or rope that goes up the stilling well, through

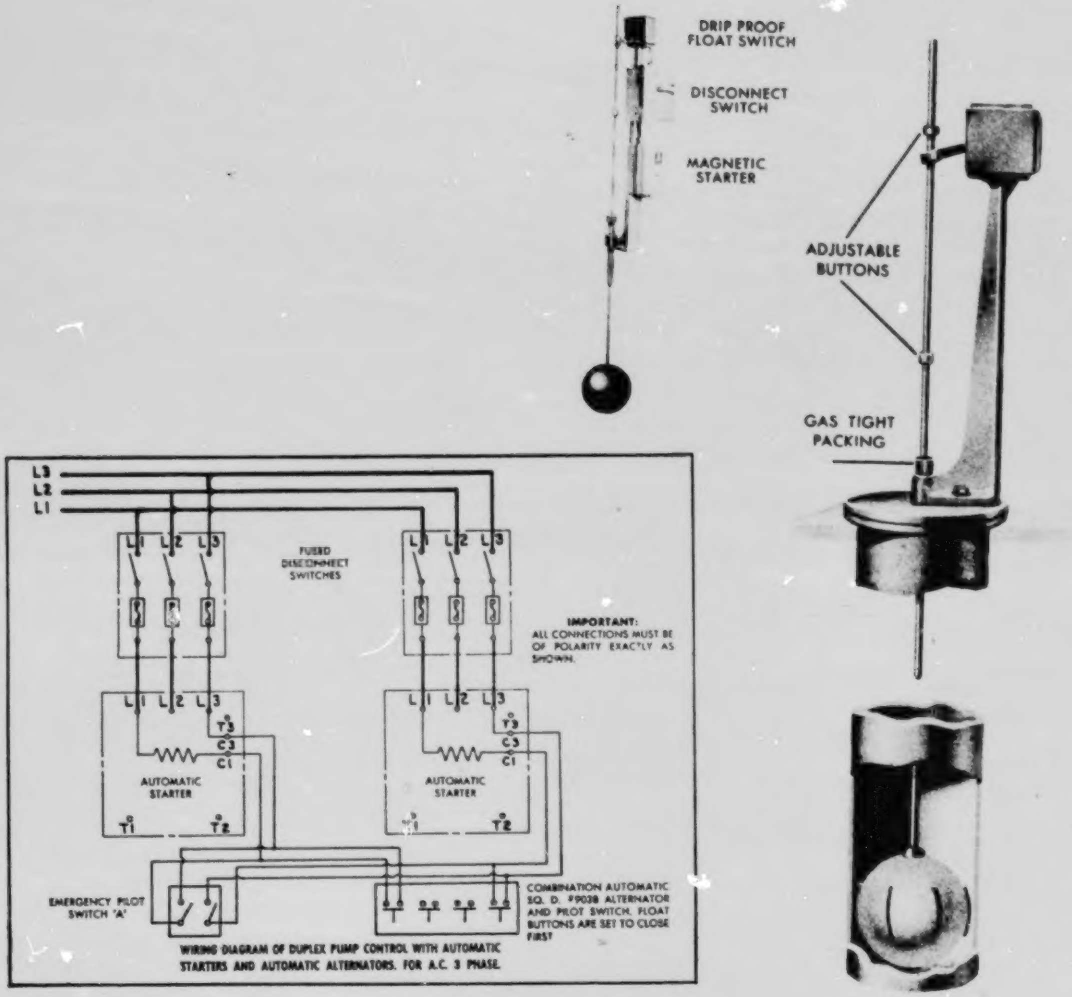
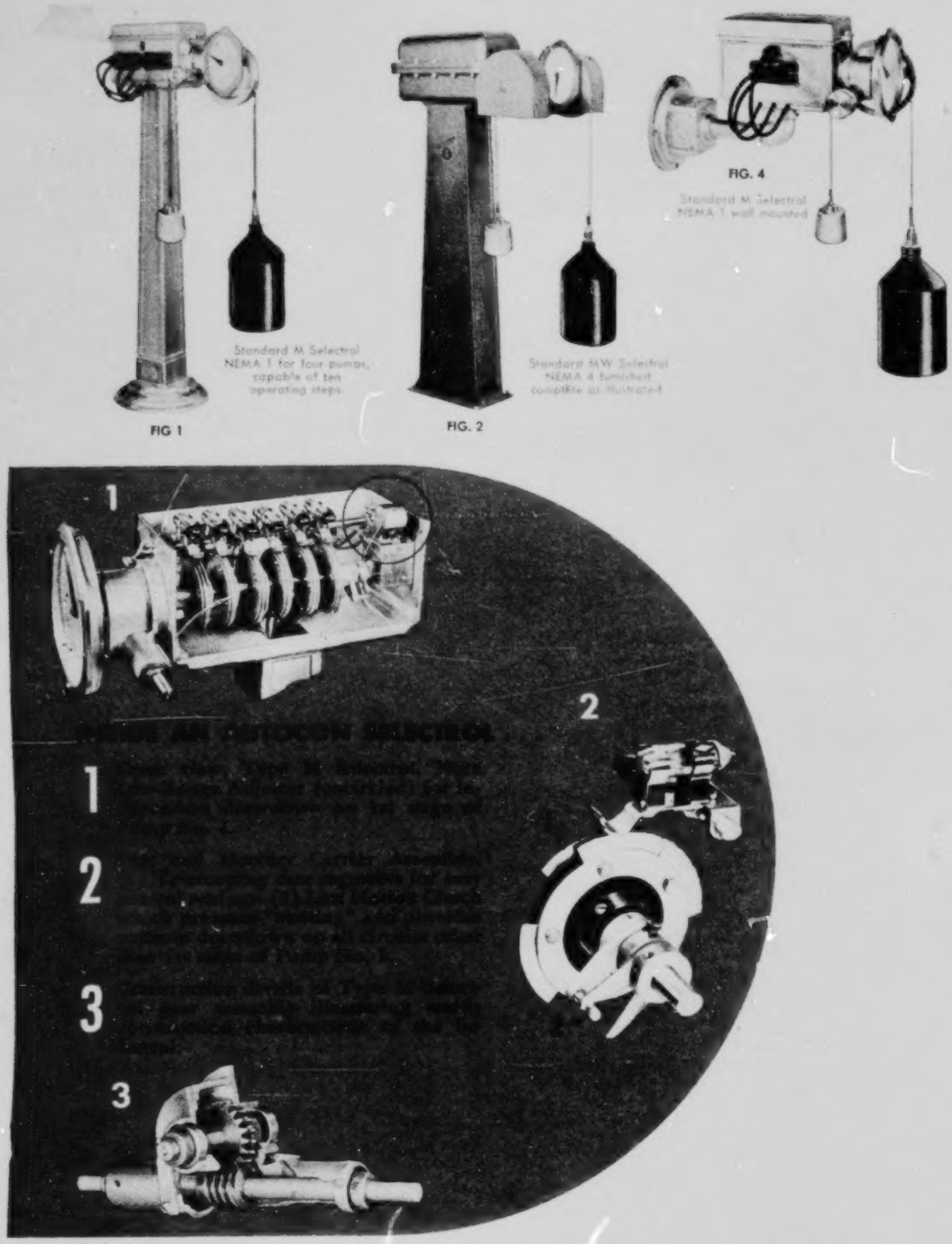

DRIP PROOF FLOAT SWITCH
DISCONNECT SWITCH
MAGNETIC STARTER
ADJUSTABLE BUTTONS
GAS TIGHT PACKING
L3
L2
L1
L1 L2 L3
FUSED DISCONNECT SWITCHES
IMPORTANT: ALL CONNECTIONS MUST BE OF POLARITY EXACTLY AS SHOWN.
T3
C3
C1
AUTOMATIC STARTER
T1
T2
EMERGENCY PILOT SWITCH 'A'
COMBINATION AUTOMATIC SQ. D. #9038 ALTERNATOR AND PILOT SWITCH. FLOAT BUTTONS ARE SET TO CLOSE FIRST
WIRING DIAGRAM OF DUPLEX PUMP CONTROL WITH AUTOMATIC STARTERS AND AUTOMATIC ALTERNATORS. FOR A.C. 3 PHASE.

Fig. 7.7. Rod attached floats and wiring diagram
(Courtesy of Weil Pump Company)



Standard M Selectrol NEMA 1 for four pumps, capable of ten operating steps.

FIG 1

Standard MW Selectrol NEMA 4 furnished complete as illustrated

FIG. 2

FIG. 4

Standard M Selectrol NEMA 1 wall mounted

1
2
3
INSIDE AN AUTOCON SELECTROL
1
2
3

Fig. 7.8. Cable attached float
(Courtesy of Autocon)

800

the cover of the wet well, and is wound onto a small drum which is counterbalanced to maintain tension on the float. When the water in the wet well rises, the float rises and the drum rotates, thus winding in the float tape, cable or rope. This rotation takes in slack in the line attached to the float and keeps the line taut. When the wet well is pumped down, the float lowers and the drum reverses direction, thus unwinding the line attached to the float. When the wet well water level rises, the float rises and the float line is wound onto the drum or sheave. This permits the counter balance to drop and rotate the drum holding the cams and mercury switch (Figure 7.8). When the drum rotates sufficiently to drop the mercury switch from contact with the cam, this allows the mercury to run down to the contact end. When this occurs, the switch closes, the pump motor starter is energized, and the pump starts. When the wet well water level drops, the float drops, reverses drum rotation and unwinds the line attached to the float. If the float drops far enough, the cam on the drum will raise the mercury switch, tilt the switch so the mercury leaves the contact end, opens the circuit and shuts off the pump.

Wet Well Rising

In a multiple pump lift station, if the first pump cannot handle the wet well inflow, the float will continue rising and at a pre-determined level established by the cam on the drum shaft, the second pump starts (Figure 7.8). If the inflow is greater than the capacity of the two pumps and a third pump is available, the third pump will start next as called for by another cam on the drum shaft. After all pumps available are running and the wet well level continues to rise, the last position on the cam often is used to transmit an alarm signal that the wet well is flooded or will be flooded soon.

Float controllers are used today for many applications due to their economical cost and ease of maintenance. The floats also provide flexibility by allowing the lift station operator to change lead pumps and pump start-up sequences in a multiple pump station every week or month or on some other prescheduled frequency. This procedure distributes wear fairly equally on all equipment by a single pump control circuit plug being moved from cam to cam output. Also this procedure could be adjusted so all of the pumping equipment will not wear out at once.[7]

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[7] "Lift Station Design and Maintenance: Room for Improvement," by Glenn Folk, Deeds & Data, Water Pollution Control Federation, Washington, D.C., June 1975, p. D-1 to 4.

Limitations of float control systems include the following:

1. Grease and debris enter the stilling well and hinder or stop the up-and-down-movement of the float. Debris can be removed from the top of the stilling well. Grease can be controlled by running clear water (hot water is better than cold water) into the stilling well at a rate of 1 to 2 gallons per minute to keep the float and stilling well clear of grease and solids. Be sure that this flow of water does not produce false readings of the wet well level unless the stilling well openings to the wet well become plugged.

FLOAT CONTROL SYSTEMS
PRO
CON

2. Float attachment line or counterbalance line breaks and unwinds from drum sheave, thus allowing counterbalance to fall and all or none of the pumps could be called on to operate.
3. Floats develop leaks which change or stop pump operation.
4. Cables or ribbons attached to float can become twisted.

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QUESTIONS

7.2G What are the two types of float controllers?

7.2H If a float is attached to a rod, what will happen if the top float rod stop is raised?

7.2I What maintenance does a stilling well require?

7.272 Electrode Controllers

Use of this method of control requires that electrodes be installed and maintained in compliance with safety regulations. The water level sensing or detecting device is simply a weighted electric lead or electrode hanging in the wet well at staggered elevations, usually six to eight inches apart. As the wet well water level rises and submerges an electrode, the water surrounding the electrode completes the control circuit and starts the pump. When the wet well level is pumped down and the electrode exposed to air, it opens the electrical circuit and shuts off the pump. One electrode controls a single pump, and each pump usually has its own electrode. A high wet well elevation electrode is used to indicate flooding of the wet well, and activates an alarm to signal a high water level or flooding.

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Limitations of electrode controllers include the following:

1. Rags and debris can wrap around electrodes and alter desired start and stop water levels and sequences of pumps.

2. Grease and/or slime can cover an electrode, thus preventing good conductivity and causing intermittent or unreliable operation.

7.273 Enclosed Electrode Controllers (Seal trode units)

These controllers are a refinement of the old free floating electrodes. They work in the same manner except they are enclosed in a two to three-inch diameter pipe with a bulb-type container on the bottom end containing an electrolyte solution (Figure 7.9).

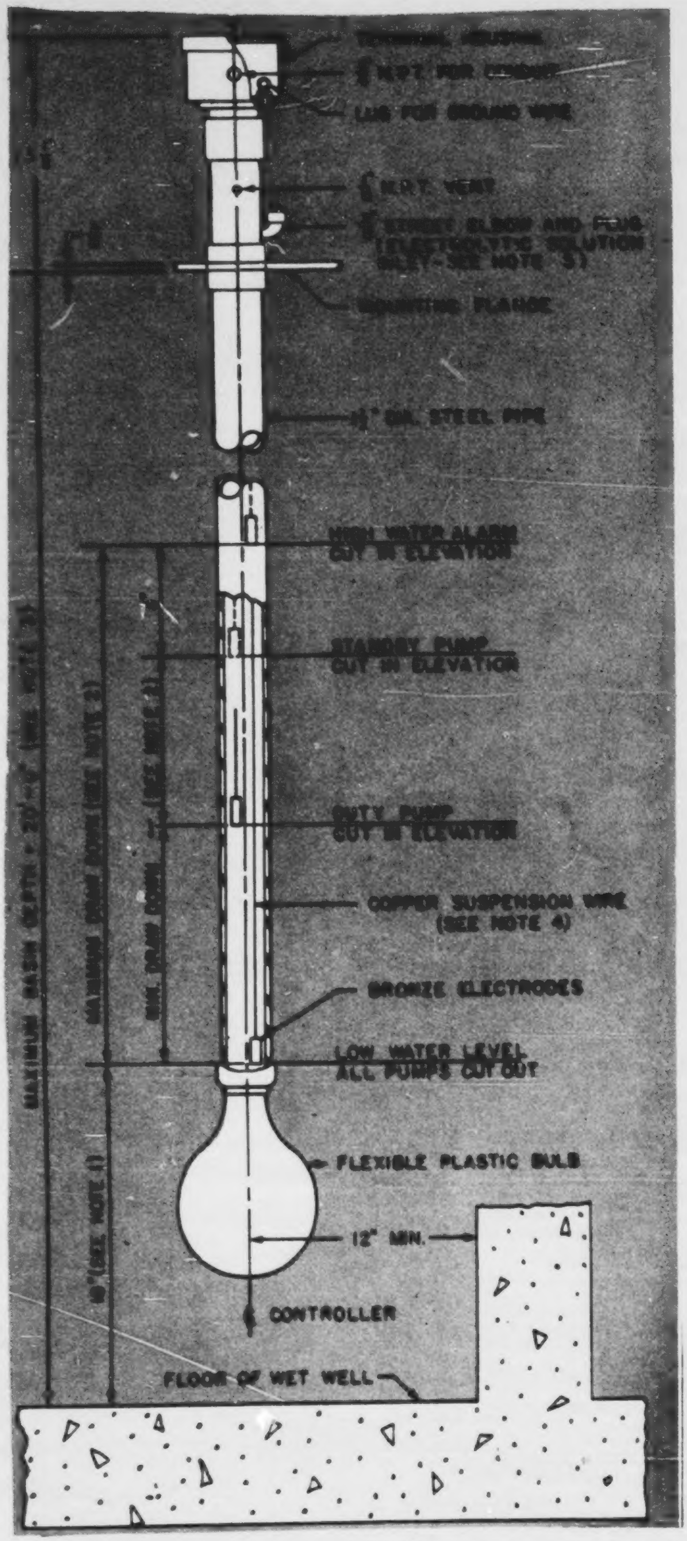
Electrodes (one for each pump and a high level alarm) are set at different elevations in the pipe housing. The bulb at the end of the pipe holds from three to eight quarts of electrolyte solution. This volume is sufficient so that water pressure on the outside of the bulb will force the electrolyte solution up the tube to an electrode that completes the circuit and turns on the pump. As the water level in the wet well rises, it compresses the bulb and forces the electrolyte up the pipe to the electrode. When the wet well level is high enough to develop the pressure required to force the electrolyte solution up the tube to the electrode, the circuit is completed and the pump is started. When the water level in the wet well drops, the electrolyte solution also falls and opens the circuit. The electrodes in this system are spaced much closer in elevation (1.5 to 2.0 inches) because the change in water pressure on the bulb is small compared to changes in water depth in the wet well.

Limitations of enclosed electrode controllers include the following:

1. When bulb breaks, electrolyte solution is lost.

2. Shorts occur in electrode wiring.

3. Bulb life is three to five years.


TERMINAL HOUSING
N.P.T. FOR CONDUIT
LUG FOR GROUND WIRE
N.P.T. VENT
STREET ELBOW AND PLUG (ELECTROLYTIC SOLUTION INLET-SEE NOTE 5)
MOUNTING FLANGE
DIA. STEEL PIPE
HIGH WATER ALARM CUT IN ELEVATION
STANDBY PUMP CUT IN ELEVATION
DUTY PUMP CUT IN ELEVATION
COPPER SUSPENSION WIRE (SEE NOTE 4)
BRONZE ELECTRODES
LOW WATER LEVEL ALL PUMPS CUT OUT
FLEXIBLE PLASTIC BULB
12" MIN.
CONTROLLER
FLOOR OF WET WELL
MAXIMUM BASIN DEPTH = 20'-0" (SEE NOTE 3)
MAXIMUM DRAW DOWN (SEE NOTE 2)
MIN. DRAW DOWN (SEE NOTE 2)
18" (SEE NOTE 1)

ENGINEERING INFORMATION

NOTE 1—18" is the minimum low water level setting for the controller. However, the actual low water setting must be set at a height to keep the pump casing flooded.

NOTE 2—The maximum overall draw down is 7'. The minimum recommended draw down setting is 6" per pump.

NOTE 3—When the basin depth exceeds 20', a 2" steel pipe must be supported by wall brackets.

NOTE 4—Suspension wires in the terminal housing have identifying labels, "A," "B," "C," etc. Wire "A" is attached to the lowest, or pump cut out electrode. Wire "B" is the next lowest, or pump cut in electrode. Wire "C", etc.

NOTE 5—Electrolytic solution consists of a mixture of 3½ quarts of clear water and one package of sodium bicarbonate.

NOTE 6—Organic acids or alcohol should not be used with the Flexible Plastic Bulb. Temperature limitations are 35°F. minimum . . . 140°F. maximum.

NOTE 7—Wires to terminals 3 and 5 must be same phase. Wires to terminals 4 and 6 must be same phase.

Fig. 7.9. Enclosed electrode controller
(Courtesy of Chicago Pump)

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7.274 Pressure Sensing Controllers (Air bubblers)

Air sensing (pneumatic) controllers are being used in many new lift stations being constructed today. They are adaptable to several different control systems and may be used in either simple diaphragm and mercury switches for control inputs, in complex fluidics (air) systems using orifices and chambers to control outputs, or in analog equipment with differential transmitter square root extraction (a method of measuring pressure) and averaging relays that convert signals from pneumatic to electronic (4 to 20 milliamp) outputs for use by controllers and integrators.

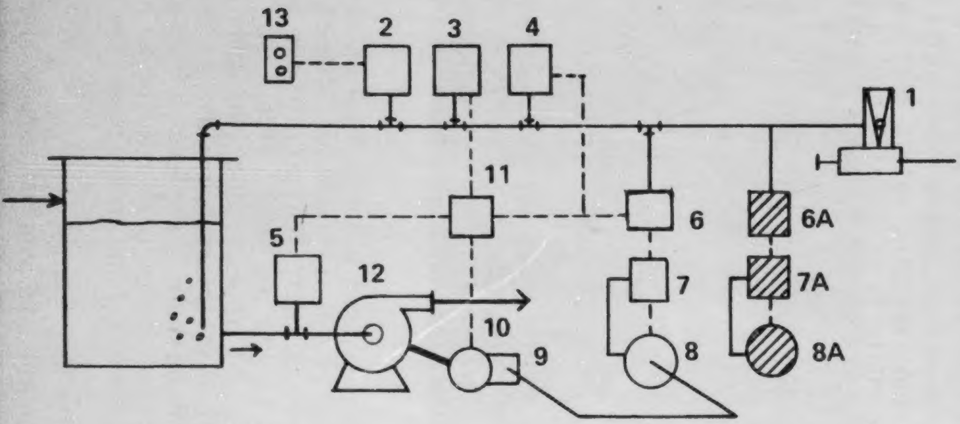
Regardless of which control system is used, the initial sensing or depth measuring device is similar. A compressed air supply is used to sense water depth, a rotometer is used to measure air flow rates, a 3/8 to 1/2-inch sensing line runs into the wet well, and a device is necessary to determine back pressure on the air sensing system (Figure 7.10).

A small lift station may be equipped as shown in Figure 7.10. Larger lift stations may take the air supply from a large air compressor receiver through a pressure regulating valve (PRV). Some agencies use small fish tank aquarium compressors for air supplies due to the expense of rebuilding small compressors. The aquarium compressor is discarded when it fails and a new compressor is installed at a cost of approximately ten dollars.

A continuous air flow is essential, but a large flow of air is not necessary. Air flows through the wet well bubbler line at a constant flow rate of one to eight standard cubic feet of air per hour (SCFH). At low water level elevations in the wet well, little air pressure is required to overcome the weight of water over the open end of the bubbler line. As the wet well level rises, more air pressure is required to overcome the water pressure. For every foot of water rise in the wet well, the bubbler system will require an additional 0.433 psi of air pressure on the air line to overcome the water pressure.

The pressure sensing device on the air bubbler supply line senses the back pressure and at predetermined set points of pressures, will start, speed up, or stop the pumps or equipment as required.

There are many manufacturers and instrumentation companies who use pneumatic systems for control, and their O & M manuals should be consulted for your type of equipment and application.



LEGEND

1. ROTAMETER WITH DIFF. REG.
2. HI LEVEL ALARM SWITCH
3. LO LEVEL CUTOUT SWITCH
4. AIR FAILURE INTERLOCK SWITCH
5. LOW PUMP SUCTION CUTOUT
6 & 6A. MODULATING PRESSURE TRANSMITTER
7 & 7A. BALANCING RELAY
8 & 8A. PROPORTIONING MOTOR
9. SPEED CONTROLLER
10. PUMP MOTOR
11. MOTOR STARTER
12. PUMP
13. ALARM SILENCING RELAY

Fig. 7.10. Wet well level measured by a bubbler/air purge system (Courtesy of Honeywell)

Limitations of pressure differential controllers include the following:

1. Air compressor failure.
2. Bubbler blockage (line must be purged regularly), tube breakage, or outlet elevation shifts.
3. Complex equipment provides more opportunity for failures and requires a higher level of training for workers to trouble shoot, repair and keep instruments calibrated. Often the more reliable an alarm system is, the more complex it becomes and thus the more difficult to maintain because of backup systems.

7.275 Additional Reading

For additional information on controls, read "A Review of Liquid Level-Sensing Techniques for Indication and Control Purposes." This Review covers 32 different techniques of liquid level sensing. Some do not differ much from others, but in those cases, the differences are considered to be significant or interesting. Obtain the Review from Consolidated Electric Company, South Lafayette Freeway, St. Paul, Minnesota 55107.

QUESTIONS

7.2J What types of controls are used to start, stop or change pumping rates?

7.2K What safety considerations are necessary when using electrode controllers?

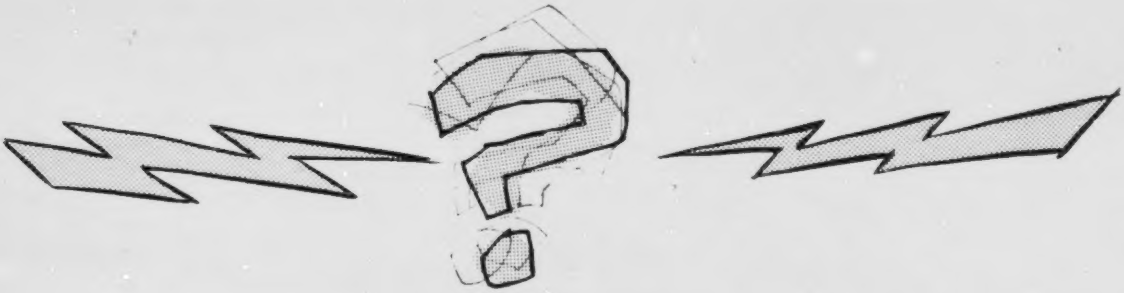
7.2L What are the limitations of electrode controllers?

7.2M How are pressure changes detected in a pressure sensing controller?

7.2N What kinds of problems can develop using a seal trode sensing controller?

7.2O How is the depth of water in a wet well measured using a pressure sensing controller?

7.2P What kinds of problems can occur with pressure sensing controllers?



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7.28 Pumps

Chapter 8 discusses pumps and has an excellent explanation of how a pump functions (Section 8.31, Let's Build a Pump). The example pump is a multi-stage high pressure water pump and would not function satisfactorily in a wastewater lift station for long periods of time. Most lift station pumps are single stage (one impeller) centrifugal pumps of the open impeller or closed two port nonclog design with minimum size sphere passage size of 2.5 inches, but preferably larger (Figure 8.14, Non-Clog Pump).

Each lift station should be equipped with at least two pumps to provide continuous operation if one pump fails or requires repairs. The pumps should be capable of being rotated as the lead pump (the pump to start first) so that equal wear may be distributed to the pumping equipment by weekly or monthly rotation of the lead pump. Some pumps have electronic controls that automatically alternate the lead pump with each start.

Each pump must be equipped with a suction and discharge isolation valve so that the pump can be isolated from the wet well or the discharge force main for draining, cleaning, repacking, and other maintenance work. The isolation valves should be gate valves. If plug valves are used in this application, problems can develop, particularly if the plug valves are not slow-closing hydraulic or pneumatic controlled valves, and the discharge head of the pumping system is above 150 feet (69 psi). Under these conditions, the discharge check valve can become blocked with rags and debris, it will not close, and the discharge line or force main will drain back through the system to the wet well. When you start to close the valve, wastewater flow will slam the plug valve shut and possibly injure you and break the valve body or a portion of the pipe system from the water hammer due to the sudden stoppage of the flowing water. To avoid these problems, shut valves very slowly. Large plug valves should have gear operators so they cannot be slammed.

Plug valves are rarely used in discharge lines because they do not provide a full opening. This restriction can become clogged with rags or sticks. If high discharge heads occur, slow-closing butterfly or plug valves operated by hydraulic or pneumatic systems are used to prevent the check valve from slamming shut and causing water hammer. For example, if a discharge line has a pressure of 75 psi and the discharge valve is closed suddenly, the shock wave (water hammer) can create pressures over 300 psi in the pipe, thus

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possibly bursting the discharge line and flooding the station. Excessive water hammer pressures can be avoided if the valve closing times are more than 30 seconds; however, the closing time should be less than two minutes.

Each pump should be equipped with a bottom volute[8] drain valve and line to the sump and a top or middle volute access inspection port for cleaning the pump. Large horizontal pumps should have a vent valve on top of the volute for priming purposes.

Seal water piping should be accessible; and if from a domestic water supply, an air gap system must be used to prevent contamination of the water that serves the public or operation and maintenance workers. Some pumps have grease seals instead of water seals to avoid the problems of having to protect a drinking water supply. The pump should be equipped with wearing rings and have provisions for inserting or removing shims in order to move the shaft to obtain proper clearance between the wearing rings and the impeller.

Sump Pump

The lower floor of the dry well should be provided with a sump and submersible pump to collect seal water and water used to hose down and clean up the area. This drainage water should be pumped out of the dry well sump and discharged at a high elevation into the wet well.

7.29 Ventilation and Auxiliary Equipment

The dry well must be equipped with ventilation equipment to maintain the dry well portion of the station atmosphere in a dry and safe environment. Ventilation equipment should operate continuously to assure a safe working access for operation and maintenance workers. A lift station dry well is considered a confined space by state industrial safety agencies and requires frequent air changes. Monitor for oxygen deficiency and explosive and toxic gases during visits to the station. Wet wells also require provisions for ventilation.

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[8] Volute (vol-LOOT). The spiral-shaped casing surrounding a pump impeller that collects the water discharged by the impeller.

In regions with high humidity, dehumidifiers may be necessary to keep condensation under control. This problem is most serious in the smaller, package-type lift stations which are of prefabricated steel. Usually the dehumidifier runs constantly, and outside air is used for ventilation only when the access cover is open. A ventilation fan can be turned on or off by a switch at the access cover. This procedure keeps moist, outside air from entering a lift station when it is unoccupied and provides the driest possible conditions.

Depending upon agency requirements or preference, lift stations also may include telemetering systems for monitoring or controlling the station operation. A flow measuring device may consist of either a Parshall flume, a weir, a magnetic meter, or a venturi meter.

The station may have emergency generator units for continued operation during electrical power failures. Large lift stations may use gas or diesel engines to operate pumping equipment due to the ease and reliability of regulating pump speed.

Some stations are equipped with individual water wells to supply seal water, water for the application of chemicals such as chlorine, or cooling systems for heat exchangers on equipment. A lift station may vary from a simple and efficient telemetered design requiring a visit once a month to a highly complex installation demanding continuous staffing.

QUESTIONS

7.2Q Why should lift stations be equipped with at least two pumps?

7.2R Why must each pump be equipped with a suction and discharge isolation valve?

7.2S Why must pump seal water from a domestic water supply have an air gap?

7.2T Why do some lift stations have an emergency generator?

END OF LESSON 2 OF 5 ON LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 7. LIFT STATIONS

(Lesson 2 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

5. What are the advantages and limitations of a wet well being too large or too small?
6. What are the advantages and limitations of having bar racks in wet wells?
7. What is the purpose of a stilling well in a wet well?
8. How is the depth of water in a wet well determined?
9. Why should isolation valves in lift stations be gate valves instead of plug valves?
10. Why must lift stations have adequate ventilation?

WHAT
WHY
WHERE
WHEN
HOW

CHAPTER 7. LIFT STATIONS

(Lesson 3 of 5 Lessons)

7.3 THE NEWLY CONSTRUCTED LIFT STATION

Many large municipal agencies do their own design work for lift stations. Smaller agencies usually rely upon a consulting engineering firm for station design. In either case, operation and maintenance workers should be given the opportunity to review the prints and specifications of a new lift station before the award of a contract for construction. This review is very important to be sure adequate provisions have been made for the station to be easily and properly operated and maintained.

7.31 Examination of Prints

When examining the prints, operation and maintenance workers should look for accessibility, not only for equipment, but for workers to get to the station. Is there sufficient space for vehicles to park and not restrict vehicles passing on streets or pedestrians on sidewalks? Is there room to use hydrolifts, cranes and high velocity cleaners as needed at the lift station? Are overhead clearances of power lines, trees and roofs adequate for a crane to remove large equipment? Is there sufficient room to set up portable pumping units or other necessary equipment in cases of major station failures or disasters? Are station doors and access hatches large enough to remove the

largest piece of equipment? Are lifting hooks or overhead rails available where needed in the structure? Has sufficient overhead and work room been provided around equipment and control panels to work safely? Is lighting inside and outside the station provided and is it adequate? Does the alarm system signal high water levels in the wet well and water on the floor of the dry well? Is there sufficient fresh water at a high enough pressure to adequately wash down the wet well? Are there any man traps or head knockers such as low hanging projections or pipes, unprotected holes, or unsafe stairs or platforms? Is there access to the wet well? If you have to clean out incoming lines, it may be necessary to put a temporary pump in the wet well. All of these questions must be answered satisfactorily if the lift station is to be easily operated and maintained.

Equipment should be laid out orderly with sufficient work room and access to valves and other station equipment, controls, wiring, pipes and valves. If there is any possibility of future growth and the station may be enlarged, be sure provisions are made to allow for pumping units to be changed or for the installation of additional pumping units. If additional pumping units will be necessary, be sure spools and valves are built now for ease of expansion. Be sure there is sufficient room to add electrical switchgear for future units. If stationary standby power units are not provided, make certain there are external connections and transfer switches for a portable generator.

7.32 Reading Specifications

Review the specifications for the acceptability of the equipment, piping, electrical system, instrumentation, and auxiliary equipment. Determine if the equipment is familiar to your agency and if its reliability has been proven. Find out what warranties, guarantees, and operation and maintenance aids will be provided with the equipment and the lift station. Require a list of names, addresses and phone numbers of persons to contact in case help is needed regarding supplies or equipment during start up and shake down runs. Be sure that the equipment brochures and other information apply to the equipment supplied. Sometimes new models are installed and you are provided with old brochures.

Be sure the painting, color coding on pipes and electrical circuits meet with your agency's practice. Try to standardize electrical equipment and components as much as possible so one manufacturer can't blame the other when problems develop. Standardization also can help to reduce the inventory of spare parts necessary for replacement. A few hours spent reviewing plans and specifications will save many days of hard and discouraging labor in the field in the future when it is a major job to make a change. Very often changes on paper are relatively simple.

QUESTIONS

7.3A Why should operation and maintenance workers be given an opportunity to review the prints and specifications of a new lift station before the award of a construction contract?

7.3B Why is accessibility to a lift station important?

7.3C What information should be determined for equipment to be installed in a lift station?

7.3D Why should prints and specifications be carefully reviewed?

7.33 Preliminary Investigation of a New Lift Station

After a lift station has been constructed, it is inspected by the contractor, the engineer, and the operating agency before final acceptance. This inspection should be planned and conducted by the people responsible for the operation and maintenance of the lift station in cooperation with the contractor and the engineer. Operation under test conditions will reveal only the immediate equipment and construction problems. These problems should be recorded on a punch list during the preliminary inspections and a copy given to the contractor. This punch list of problems should be quickly corrected so the station can be ready for service. Do not accept any portion of a new lift station, because official acceptance of completed work is the engineer's job.

To obtain maximum life and use from a new lift station, begin the

station preventive maintenance program now when it is new. Start the program by filing data in a station record book. Record station identification code number, location by map and street numbers, date of construction, size of station by flow capacity and other important information required by your agency. Also file a set of plans and specifications for reference purposes.

Start the preventive maintenance program by making a complete list of all equipment at the station. See Chapter 8, Section 8.28, Records, for typical data sheets. Information recorded should include equipment name plate data. Mark each piece of equipment with an identification code number and record the number. There should be a minimum of two copies of this information. Keep one copy at the lift station and the other in the station record book at the agency office. Once this has been done, permanent identification of all equipment involved in the station will be available when needed. Prepare a spare parts list and order any extra parts now.

Record keeping must begin when the station is first started so that any peculiarities of the equipment are known from the beginning. These records should include any of the contractor's data collected during construction and also data required according to the specifications. These specifications include:

1. Equipment manufacturers' O & M manuals.
2. Engineers O & M instructions, including detailed emergency procedures.
3. Pump and motor operational characteristics.
4. Pump and motor coupling alignment readings.
5. Wet well control levels.
6. Auxiliary equipment data.

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QUESTIONS

7.3E Who should inspect a lift station after it is completed, but before it is accepted?

7.3F Where should information regarding lift station equipment and performance be filed?

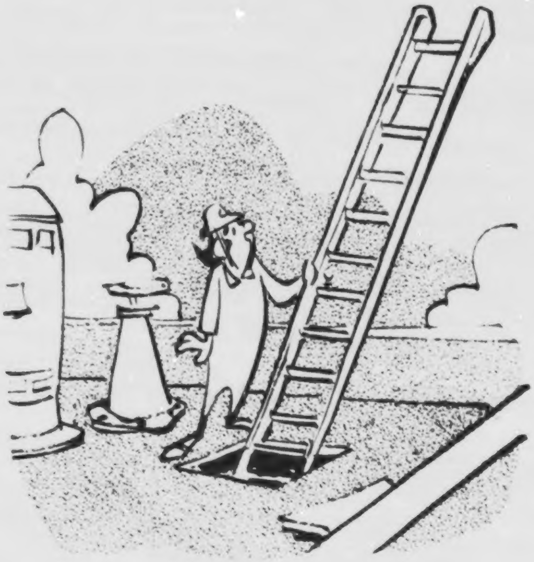
7.3G Why should data from initial tests on equipment be recorded and filed?

7.34 Inspection of Lift Station

Hopefully you had the opportunity to review the plans and specifications for the new lift station. Now is the time to determine if the station was built as you wished. Look at those items you previously reviewed. Ask yourself what problems will be faced when maintenance and repairs are to be carried out under adverse conditions. Think of the worst situations so that your preparations will be adequate when needed.

Inspect the building for access so equipment can be removed. To insure that equipment can be worked on, the following items must be considered. Is there an emergency lighting system and is it adequate? Is there enough head room to pull pumps, motors, gear heads or other pieces of equipment? If head room is not needed, are the passageways wide enough to allow for the removal of gear boxes, engines, control panels, and standby generators? If pumps have to be removed through the roof of a building, do we have clearance for a crane or other lifting device to get within reaching distance? Where are the electrical lines located that supply the building? Will they restrict use of the lifting equipment? The time to consider all of the above is now, not when conditions are adverse. If there are potential problems related to equipment removal, the time to correct these problems is now. Plan to conduct corrective work before a crisis occurs. Don't wait for an emergency to arise to discover that a critical piece of equipment can't be moved when a unit needs repair. Dismantling equipment in place under restrictive conditions is slow and difficult work.

The next unit to inspect is the wet well. What kind of conditions will be encountered when you attempt to clean the sump or possibly to enter it and remove grit? In a sanitary wet well, are there enough openings for washing the sump walls and floor? Can it be ventilated easily? What type and size of ladder will you need for access? If there is a bar rack, or comminuting device, consider the conditions you will encounter to clean the rack and how you will dispose of the debris. Also consider the tools needed and whether or not the necessary tools will be stored at the site. If tools must be transported, make notes of what will be needed and how transportation will be accomplished. Inspect the equipment that measures the water level in the wet well.



Before entering any lift station or other wastewater facility, safety procedures must be followed to insure that the hazards encountered will be eliminated or brought to a minimum. The hazards are as follows:

1. Insufficient oxygen.
2. Explosive and toxic gases.
3. Poor footing caused by grease or slimes.
4. Unsafe stairs and walkways.
5. Dangerous electrical gear.
6. Inadequate drainage.

If the wet well is to be entered, begin by setting up a blower that will give a minimum of two air changes a minute within the wet well. The wet well must be washed thoroughly using a hose with a nozzle. After washing has been completed, the wet well can be monitored for toxic or poisonous gases, explosive gases, and lack of oxygen. If all conditions are satisfactory, then and only then is it permissible to enter the wet well. All of the safety equipment and clothing listed under safety for confined spaces should be available for use at this time (see Chapter 9, Section 9.5, Manholes and Other Confined Spaces). Monitor the wet well gases and oxygen continuously until the job is completed and everyone is out of the sump.

QUESTIONS

7.3H What problems may be encountered when cleaning a wet well?

7.3I What are the hazards found in confined spaces that handle wastewater?

7.3J What can you do to eliminate or reduce to a minimum the hazards encountered in sumps?

The next item to inspect is the electrical equipment. Begin by recording all name plate data. Put code numbers on each panel beginning at the main breaker. Branch panels that supply power to major circuits carry the code number of the piece of equipment that it serves. A lighting branch panel has its own listing or numbers and the lights or plugs it serves also carry this number. With a system like this, the problem of locating controls, plugs, and lights is quite simple.

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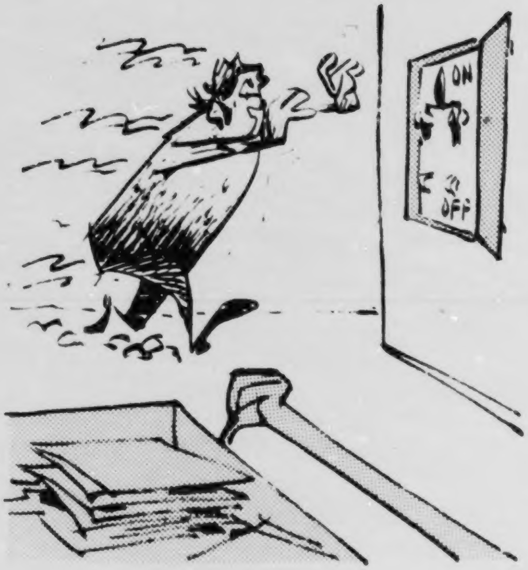
Individual inspection of the major circuits is necessary. Record the parts that most likely will need attention during an emergency. All fuses must be listed and spares kept at the station. Data on switches, relays and heater strips must be recorded. Be sure that all overload heaters are the proper size. Control circuit equipment must be listed. Identify all related equipment with proper code number.



Make this inspection with the main breaker to the equipment being inspected locked in the OFF position. No attempt should be made to inspect or repair electrical equipment unless a basic knowledge of electricity and the safety precautions needed are fully understood and applied. Request an electrician to help if you are not qualified or not authorized to inspect electrical equipment, circuits and controls.

After listing all necessary data and putting code numbers in place, read the operating instructions and examine the controls for their proper operation. Move all switches with the power off to see how they operate. Check reset buttons and know what they are supposed to do. Before the station becomes operational, it is essential to learn how things are supposed to work.

The approach to solving any problem must be made with logic and caution. Be deliberate and think each step out before making any changes. Mark all settings, if possible, so that you can return to the starting point. Wait a short period when changing settings to obtain and observe the results. Do not make a change if you think it is not safe.

Before leaving the electrical equipment, tag any dangerous area with "not to be tampered with or touched by inexperienced hands" and lock out.

QUESTIONS

7.3K Where should the inspection of the electrical equipment begin?

7.3L When inspecting an electrical circuit or equipment, in what position should the main breaker be positioned?

7.3M Should there be extra fuses kept at the station? Why?

7.3N When should you learn how the electrical circuits work?

The next point of inspection is the pumps. All name plate data must be recorded. Lock out pump and determine direction of rotation. If local electrical utility company has worked on their lines near the station, be sure the power leads (legs) are hooked up correctly and the rotation of the pumps is in the proper direction. Inspect the backspin preventer if the pumps are so equipped by trying to turn the pump shaft in the direction against the indicated rotation. Backspin equipment operation also may be detected by listening to the pump motor when the unit is shut down after a run. When the unit comes to a stop, the backspin unit begins to engage and it can be heard as a ratcheting sound. If a right angle gear head is used, the backspin equipment may be located on this unit. Equipment specifications will have to be checked to determine if there is anti-rotation equipment provided in the gear head. Examine all gages for location and determine at this time what they are to indicate. Any valves located on the suction or discharge should be opened and closed to examine for correct and easy operation so that you are familiar with them. Place equipment numbers on these valves so that a preventive maintenance card can be made to

service them. Maintenance record cards should be prepared for each piece of equipment inspected. Inspect the drive and pump for proper alignment. If belt driven, record the sizes of the belts and numbers so that spares will be available when needed. Inspect all rotating parts for missing guards and secureness. The guards must be built for easy access to the equipment being shielded, but still meet all safety requirements.

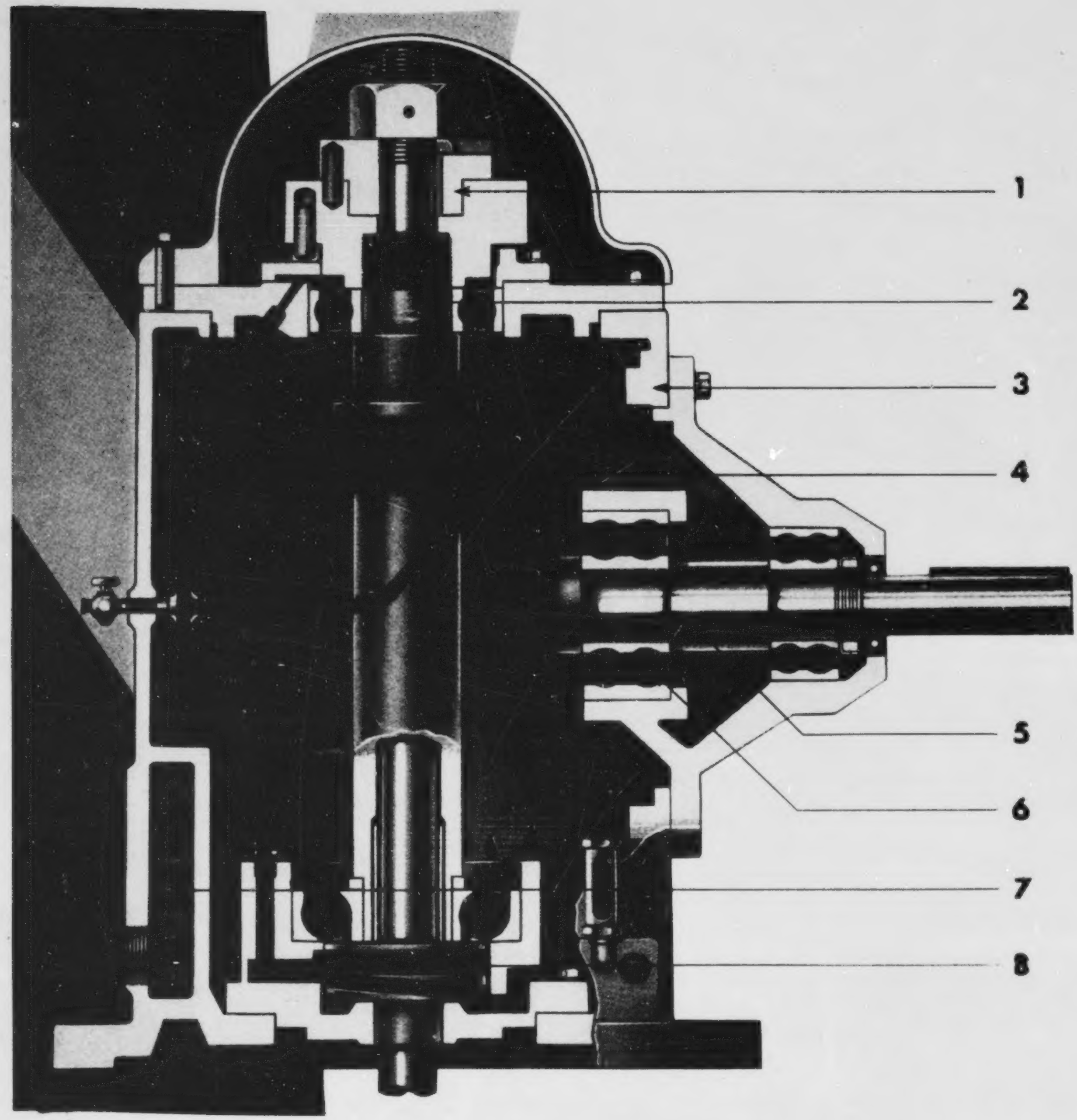
Inspect the lubrication equipment used and note all pertinent information needed to keep it operating. Solenoids used to operate the oilers should be standardized when reviewing the specifications in order to reduce the inventory of spares necessary for replacement.

Inspect suction and discharge lines. The suction line must be kept clear of debris. If a check valve is supplied on the pump discharge pipe, this valve can become a problem when stringy material gets caught on the flapper and it stays in the open position.

If the lift station uses gasoline or diesel engines, they may be in the form of stand-by generators or as a pump drive. When used as a pump drive, the operation may go through a right angle gear unit (Figure 7.11). These units are used to keep a large engine from being located on a lower deck where the pump must be located for efficient operation. The engine is kept on the top floor for easy access, cooling, ventilation, exhaust, and above the level of flooding.

There will be very few problems with the right angle gear if the proper design unit is used for a given job. The most important point is to have the proper lubrication for the gears. Preventive maintenance will maintain the unit free of leaks. Cooling is supplied to some units, but only when the gear head is to run continuously for a long period of time. You must inspect the drive shaft and its universal joints. Lubrication is necessary, but should be kept to a minimum because too much will rupture the seal on the universal and cause failure by allowing the entrance of foreign material.

The engine must be inspected for sufficient oil, water and fuel to operate properly. Without any of these, the unit will not function properly. Examine the battery for water, tight cables and clean terminals. If the engine is large and requires compressed air for starting, inspect the auxiliary air system. Inspect and adjust alarm system for proper operation at the predetermined points of alarm or shut down. Failure of the alarm system or shut down devices could cause an engine to burn up. Make sure that all hoses are secure and clamped tight. Loose nuts and bolts must be tightened. Be aware of the ones that continually become loose. A different type of fastener may solve this problem.



1. Clutch
2. Vertical output shaft assembly
3. Housing
4. Gear and pinion
5. Horizontal input shaft assembly
6. Anti-friction bearings
7. Cooling
8. Lubrication

Fig. 7.11. Right angle gear drive

(Courtesy of Fairbanks-Morse)

Leakage of any sort should not be tolerated. Keep cleaning equipment at the station to keep leaks wiped up so that you know when a new leak starts. Vibration will continually cause problems of leakage and loose parts, so you must never let up on your preventive maintenance program.

If there is a clutch to disengage the engine from the drive shaft, test its operation. It should be a little hard to engage and disengage because the unit must snap over center when operated.

Lubrication of the clutch throw-out bearing should not be excessive because the friction plates will fail if contaminated with grease. The engine should be maintained as you maintain your automobile engine. Change the oil on a regular schedule to remove contamination from the engine's inner parts. Inspect the oil for metal filings and sludge when changing the oil to stay aware of the engine condition. If filings are noted, a failure of bearings may be assumed. Look for water or an oil-water emulsion that indicates water in the wrong place. If a qualified lab is available, oil may be tested to determine when a change is necessary.

Sludge indicates that excessive dirt or carbon have found their way into the crankcase. This may be a failure of the engine's breathing system or just plain blow-by at the rings. Engines should be run from two to four hours during extensive test runs to permit complete heating of all parts and to observe performance during continuous operation. Inspect the engines' heating and cooling systems. Short runs of 5 to 15 minutes should be avoided (especially with large engines) because this is when the most damage can be done to a cold or not properly heated engine. If the engines are not being used, they should be test run monthly for four hours carrying a typical load.

Determine what type of fuel is to be used and the storage capacity, the engine's consumption rate, and when the fuel will be delivered. The fuel tank should be kept full so condensation won't collect on top of the tank.

Inspect all controls for free and easy operation. Make a record of their settings before and after operation. This becomes the standard and a starting point for trouble shooting when problems occur in the future. When operating, set marks can be made with fingernail polish at the set point. The question may arise at this point as to why bother to check everything on the engine so thoroughly? Inspecting and obtaining a standard for the engine will help tremendously when problems do occur. The jobs of trouble shooting and repairing become easy when there is good data for reference. This data can be obtained only when the engine is new or rebuilt and is being operated for the first time.

The final point of inspection is the housekeeping needed to maintain an acceptable station which will satisfy the public or surrounding area. Inspect all fences to see that they are complete and have a neat appearance. If made of wood, be sure the paint has good color and is protecting the wood. Chain link fences usually require little maintenance, but should still be inspected for damage or poor installation. Metal chain link fences must be grounded in case a power line drops across them and an unsuspecting worker goes to open the gate. Examine all paved areas for proper drainage and good workmanship when an area is paved. Inspect unpaved areas for weed control.

Examine all exterior parts of buildings. Look for poor installation or possible future problem areas. At this time, get a ladder and inspect the building's roof. Be sure that all openings are adequately covered or louvered.

QUESTIONS

7.3O What is the purpose of anti-rotation equipment on a pump?

7.3P What can happen if a universal joint is over lubricated?

7.3Q What can happen to an engine if its internal alarm system fails?

7.3R What must one look for when changing engine oil?

7.3S Why is the engine examined so thoroughly?

7.3T What precautions should you take when lubricating the clutch throw-out bearing?

7.3U What causes condensation to form inside an engine?

7.3V What three items must we have for engine operation?

7.32 Operational Inspection

We are now ready to operate the lift station. Open any valves on the influent line to fill the wet well. Make certain that the pump volute drain lines and vent lines are closed. If there is no wet well, open the valve to the suction side of the pump. Inspect the sump and bar rack at this point for debris and free flow into the station. Remove the floating debris left by the contractor in the sump or off the bar rack that you should have removed BEFORE the station was placed in service. Problem materials include small pieces of wood, like grade stakes or pieces of plastic of any size, cans, and bottles. Some objects can plug off the eye of the impeller.

With the sump filling, inspect your sump level indicator to see that it is working properly. If there is no indicator, visually check the sump level or watch the rise in the pump control stilling well. If a bubbler system is used, watch the pressure gage indicator and verify wet well level readings with actual readings. Once the station is in operation, the determination of the sump level will become a part of the normal inspection for system maintenance.

Inspect the discharge side of the pump for clear passage of the liquid to be pumped. All valves must be open. Bleed air from volute of pump. Sumps usually fill slowly unless a means of causing rapid filling can be found, such as using water from a fire hydrant.

When the sump is filling, recheck for power to pump and proper rotation of the pump. If an engine is the power source, it must be checked out before operating. Put the pump on manual operation and momentarily start pump. Watch rotation of pump shaft to see that rotation is correct. There is usually an arrow attached to the side of the pump to indicate the proper direction. If there is not, you will have to refer to the manufacturer's manual to find out how to determine correct rotation. Another means of determining rotation is to take a load check of the amperage drawn by the pump motor and compare this value with motor name plate data. If the rotation is in the wrong direction, the amp reading will be lower than the motor rating due to less work being done by the pump by rotating backwards. Lower amp readings also can result from head conditions lower than design head conditions. If the discharge flow is low or the wet well is being drawn down slowly, the rotation could be in the wrong direction.

Now that the rotation is in the proper direction, the next job is to see that all operating controls are put into the automatic position for the test operation. Start by examining all automatic switches to see that they have been put into the automatic position. Circuit breakers must be checked to see that they are in the on position. Oilers or solenoids operating the oilers should have been inspected during previous inspections. The electrical alarm systems must be examined to see that they are in the activated position. The electrical components of an engine must be inspected to be sure

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that there are no drains on the battery. The mechanical inspections should include inspecting all valves to see that they are open or closed according to the operation desired. You must be sure that all oilers have been filled and are not dripping. If a bubbler system is used, an inspection should be made to determine that it is functioning properly and that there is enough air pressure provided to make the control system operate.

Other mechanical checks should be made on the engine. Determine that the linkage is ready to operate. Inspect the clutch to be sure that it is engaged. Examine all cooling water valves to see that they are in the proper position.

Check to see that preheaters (if provided) on the engine are operating. The heaters inside the building should be examined to see that they are functioning to maintain the proper humidity and temperature within the station. Up to this point we have been recording all the data that have been observed. This information becomes your base for future operation reference.

Notify operators of downstream lift stations and wastewater treatment plants that the lift station is being tested and tell them the volumes of water that can be expected. Allow the sump to fill and activate the station. Watch the level of water in the sump to be sure that the pump starts at the desired level. If not, adjust this operating point by whatever means are available.

The pump must be stopped after being started so as not to pull the sump level down too far. When the starting point has been set by a visual or simulated means, we can continue to the next point of operation and that is to allow the sump to continue to rise. If more than one pump is involved, each start position for each pump must be determined and recorded as the level rises until all start points have been activated. Allow the level to rise and activate the high level alarm.

At this point you may now start the pumps in their reverse order. Each pump when started must be inspected for its operation and all data recorded. The first item to inspect is the electrical load on motors. Record any electrical malfunctions and have them corrected. The pump should be inspected for proper operation and any unusual noises or vibrations noted along with excessive heating.

Inspect the packing gland or mechanical seal. If the unit has a mechanical seal, there should be no leakage. If it is a packing gland, get the data on size of packing needed. Set packing so that there will be leakage of approximately one drop per second. If the packing is Teflon, you must adjust the gland tight with your fingers and run the pump 15 to 30 minutes while you watch the packing gland. Teflon will expand. Do not tighten gland during this period of operation. You are watching to see that it does not get hot. After this period of operation, adjust the packing gland nut one flat[9] tight by turning bolt one flat on nut. Maintain one to three drops of water per second on the packed glands. No more adjustments are necessary. If leakage continues excessively, something wrong was done when the unit was packed and it must be repacked.

Most packed seals have flushing water supplied to the seal. The pressure needed here is 3 to 5 psi above the pump discharge pressure. There should be a filter in the flushing line if the water being pumped is used for this flushing water. Obtain all the information needed to service the unit and to have spare parts available.

Do not operate any unit if you think it is not functioning properly. Shut it down and have the contractor examine the problem. When the problem is corrected to your satisfaction, you may proceed with the test operation. All gages should be inspected and their set points recorded. Continue with the individual operation of all pumps until they have been checked out to your satisfaction. They must comply with the specifications and operate on the performance curves as intended by the design engineer.

When all data have been recorded, shut the pumps off and allow the wet well to refill. When full again, operate the pumps to adjust the shut-down points. It may be necessary to operate more than one pump to pull the sump level down. While pumping the level down, observe the pumps in operation and record any unusual conditions. With all set points adjusted, operate the station on automatic a number of times through the full range, observing what happens and recording the results. Too much information is better than not enough. When you are satisfied that the automatic system is operating in a consistent manner, notify the engineer that the lift station is acceptable to you and you wish to put it on line.

During the first few weeks of operation, frequently inspect the equipment. Bearing failures and other problems may develop after a few days of operation.

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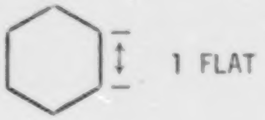
[9] Flat. A flat is the length of one side of a nut.



QUESTIONS

7.3W How much leakage should there be from a packing gland?

7.3X Are there any special precautions with Teflon packing?

7.3Y What minimum pressure is needed for the flushing water on a mechanical seal?

7.3Z What would be the first thing that you should do before operating the station?

7.3AA Should you bother to remove the debris left in the sump?

7.3AB What are the ways or means used to determine whether the sump level is rising or not?

7.3AC How do you inspect pump rotation?

7.3AD Is it necessary to inspect all points of operation if there is more than one pump located within a station?

7.3AE Should you continue operating a unit if you feel it is not functioning to your satisfaction?

7.3AF Why is it necessary to record all data when test operating the station?

END OF LESSON 3 OF 5 LESSONS ON LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 7. LIFT STATIONS

(Lesson 3 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

11. How would you examine or review a set of prints and specifications for a new lift station? or What items would you be sure were satisfactory from the viewpoint of operation and maintenance workers?
12. Who should inspect a newly completed lift station? and What items should be inspected?
13. When should a preventive maintenance program be started for a new lift station?
14. What items would you inspect in a new engine in a lift station?
15. How would you make an operational inspection of a new lift station?
16. What would you do if an operating unit is not functioning properly?

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CHAPTER 7. LIFT STATIONS

(Lesson 4 of 5 Lessons)

7.4 OPERATION OF WASTEWATER LIFT STATIONS

After a lift station has been constructed and put into operation, it is the responsibility of the operating agency to insure the continuous and efficient operation and maintenance of the lift station, including the structures and the grounds. This responsibility includes preventing failures in operation that would result in flooding upstream homes, businesses or streets. Responsible design includes no facilities for by-passing wastewater to rivers, streams, lakes or drainage courses. When emergencies occur, portable emergency equipment must be used to pump the wastewater to a functioning section of the downstream collection system and not to the environment. When untreated wastewater is discharged to the environment, public health hazards and pollution of adjacent receiving waters result.

Lift stations may be located throughout a community and must be neat in appearance, blend with the architecture and landscaping of the neighborhood, and not create a nuisance to neighbors through odors or noise. Complaints from the public will be few if the workers responsible for the lift station maintain the facility in top operating condition and respond to questions or complaints from the public in a positive and concerned manner. When responding to a complaint, be sure to tell the public what has been done or will be done to correct the complaint.

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7.41 Lift Station Visits by Workers

One rule that should apply to all lift station visits is that for safety precautions, there must always be two workers making the station visit. Many state OSHA agencies consider a wastewater lift station a confined space. Safety precautions regarding the potential presence of hazardous gases apply not only in the wet well, but in the dry well area of the station too. This rule must be obeyed during off-duty hours such as nights, weekends and holidays when workers are responding to lift station telemetry alarms. Always take the few extra minutes to pick up the required additional crew member. The additional effort is critical and worthwhile when compared to the sorrow and costs that result from an injury or a lost life.

The two-worker crew usually consists of:

1 Maintenance Mechanic I
1 Maintenance Mechanic Helper

QUESTIONS

7.4A How can nearby streams and rivers be protected from wastewater when a lift station fails?

7.4B How can complaints from the public about a lift station be minimized?

7.4C What is the most important rule that always must be considered when visiting a lift station?

7.42 Frequency of Visits to Lift Stations

A rule cannot be developed for determining the frequency of visits to lift stations for operational inspections. The frequency of lift station visits varies by community and may range from continuously staffed pumping plants, twice daily visits, once a day, two to four times a week, once a week, to once a month visits.

Frequency of lift station visits depends on the following:

1. Number of stations in the community.
2. Type of wastewater being conveyed.
3. Potential damage resulting from storms flooding station.
4. Condition of equipment, such as equipment temporarily repaired and waiting for replacement parts.
5. Design of facility and equipment installed in the lift station.
6. Adequacy of preventive maintenance and overhaul program.
7. Type, adequacy, and reliability of telemetry system.
8. Attitude of operating agency towards operation and maintenance.

The attitude of the operating agency is probably the most significant factor today in determining the frequency of lift station visits. Many operating agencies make daily visits to their stations because they have always visited lift stations daily and also because they know that a great number of other communities make daily visits. However, have the people responsible for station operation and maintenance analyzed their collection system and their operation and maintenance programs and proved that daily station visits are required? To conduct this type of analysis, records must be kept and studied in order to answer the following questions:

1. How many station failures are found each day?
    a. Electrical power failures.
    b. Failure of level sensing or other control equipment.

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c. Flooded wet wells.

d. Plugged pump impellers or lines.

e. Overheated and tripped out motor thermals.

f. Sump pump off and sumps or dry wells flooded.

g. Air or gas bound pump.

h. Stuck or blocked check valve.

i. Pump control systems not functioning.

j. Failure of lift station telemetry system.

k. Ventilation fans burned out.

2. What functions were performed at each lift station that kept the station operating, and what would have occurred if the function had not been performed during the daily station visit?

   For example, assume a pump impeller was plugged with rags and not pumping. The station crew during their visit and inspection discover the problem, derag the pump and restore the pump to service. However, if the pump had plugged immediately following their visit, the telemetry system would have indicated a failure. This crew or another crew would be dispatched to return to the station. If the pump was not telemetered, the back up or alternate pump would have pumped the wastewater until a high wet well level was reached. At this point a high water level alarm would have been activated or the other pump would have handled the flow until the next day when the crew again routinely visited the station. Therefore, with an adequate telemetry system, a routine visit is not essential under these conditions.

3. How many actual man hours of work is performed at each station during the visit? Do not include crew travel time to the station.

4. What is the critical period of time if the station does fail?

   This time period is the length of time from when the failure occurs at high water level in the wet well to when back up flooding or overflow will occur. When this critical time is determined (it should be reevaluated annually because flow conditions change), it provides the time available for a station crew to respond to an alarm condition. Any critical time under one hour creates a serious problem for the operating agency and corrections should be made by installation of larger pumps. If power failures are a problem, an emergency generator should be installed to operate the station during power failures. Another possibility is to staff the station on a continuous basis and to operate with manual controls or overrides during power failures.

Lift stations operate automatically and, if properly designed and maintained, do not require daily visits under most circumstances. Typically the daily visit is usually a quick inspection of the power panel for tripped breakers, indicating lights of operating equipment, flow data and recording elapsed time meter readings. Motors in the station are usually examined to see if they are noisy or running hot. Items typically checked during a visit include the pump packing or seal system, check valves, and suction and discharge pressures, routine lubrication and clean up. The sump pump switch is flipped to see if it is operating. The visiting crew may bleed condensate from the air bubbler system for wet well and pump control and glance at the wet well indicator to see if it is reading properly. The crew may look into the wet well for sticks and even observe that there is water in it.

Unfortunately this description of a lift station inspection is not uncommon even when performed by competent and well qualified workers. Daily visits tend to cause workers to give the station a quick glance in a noncritical manner because the crew was here yesterday and will be back tomorrow. For this reason, important maintenance items are often delayed until tomorrow which sometimes doesn't come for a month. Stations that are visited daily may be dirtier and more in need of maintenance than stations visited less frequently. If a lift station requires a daily inspection, the station book should have a daily task check off sheet indicating the tasks to be performed and a space for the initials of the person who performed the task to indicate who did the job.

A very important aspect regardless of the frequency of visits is the fact that operating and maintenance workers must be provided the time and training to adequately perform each task. Also supervisors must occasionally inspect stations after a crew visit to see that the tasks were performed and not merely signed off. Once procedures and objectives have established that specified tasks must be done on a routine frequency (whether daily, weekly, monthly, quarterly or annually), the workers responsible for the lift station must accept the responsibility and be sure the task is completed when scheduled so the operation of the lift station will be as reliable as possible. Analysis of records can indicate if adjustments in the frequency of tasks are necessary.

Small communities with one or two lift stations may find it more economical to visit stations twice daily rather than to install and to maintain a telemetry system. When the operating agency has 15 to 50 lift stations to operate and maintain, then the time consumed for the single daily visit becomes very large and quite expensive. If it is possible to reduce station visits from once a day to once a week, the savings are substantial. Monthly station visits are practical, but visits at greater time intervals are not cost effective.

This chapter is not attempting to convince every operating agency to extend lift station visit frequencies, because this is not applicable to every station. It is attempting to indicate that many people have little confidence or no faith in their lift station's equipment and programs and do not believe that a station can operate a week, let alone 30 days by itself. Sacramento County, California, has been successfully operating lift stations with monthly visits for over ten years with relatively few problems. In fact there are fewer problems than when the stations were visited on a daily basis.

The following is a list of requirements that must be met to permit limited visits to lift stations of once a week to once a month.

1. Equipment lubrication reservoirs must be large enough to hold lubricant supplies to meet needs between visits to the station.

2. Telemetry of the station is required. Most lift stations constructed today are telemetered at least for the high water alarm. Usually other items may be sensed and alarmed on the same high water alarm signal, for example:

   a. Water level in sump pump pit of dry well.

   b. Power failure.

   c. Air compressor failure.

   d. Lift pump check valves. (When pump motor starts and check valve does not open, an alarm sounds indicating a pump failure.)

   e. In stations using other auxiliary equipment necessary for station operation, the following additional items also may be sensed and telemetered:

      1) Water supply pressure.

      2) Chlorine leaks.

      3) Low chlorine pressure.

      4) High temperature of motors and engines.

      5) Worker inside stuck elevator.

Regardless of the malfunction, the station can be telemetered so any serious failure can trigger an alarm that indicates a crew should visit the station immediately. The dispatcher does not know the nature of the problem, only that a crew should go to the station. The crew makes the necessary corrections or adjustments and returns the station to normal operation. When the problem is corrected, the alarm signal will shut off. The most serious problems with telemetered systems using leased phone lines are with the phone company having trouble keeping the lines working properly. If the failure of a lift station is critical, back-up transmission systems may be needed. There are other ways to transmit telemetry signals, for examples microwave, radio transmission, or privately owned transmission lines. Only large and adequately funded agencies can afford their own transmission lines.

QUESTIONS

7.4D What items or factors influence the frequency of lift station visits?

7.4E What are the different types of lift station failures?

7.4F How is the critical time for a lift station after failure determined?

7.4G When is a daily visit to a lift station required?

7.4H What requirements must be met for a lift station to perform effectively and only be visited from once a week to once a month?

7.43 Essential Tasks During Lift Station Visits

The only time a lift station should be visited is when it is toured by visiting dignitaries from out of town or by management inspecting the facilities. Neither of these two groups nor any other tour group tend to significantly add to the functional capability of a well maintained lift station. So as not to be misleading, let's define the term *visit*. There are two other types of station visits that are significant:

1. To perform scheduled routine preventive maintenance upon the equipment and the station.

2. To respond to a lift station alarm or emergency condition to restore the station to operation.

If there is a *good preventive maintenance program* and the *frequency schedule* is at the proper intervals with clear duty assignments in writing and completion verified by management, then there will be only a few occasions when a crew must respond to an alarm.

In this section we have attempted to convey a very important fact - - wastewater lift stations can be capable of operating automatically. Proper maintenance will allow these stations to operate automatically for long time periods.

Why have many lift stations been visited daily? Probably because they were run by operators of wastewater treatment plants. Wastewater treatment plants are complex facilities requiring daily observation and regulation of treatment processes. Fortunately most small lift stations are not as complex and can be designed and maintained in a manner that allows the station to perform its functions automatically and without daily visits.

Note that the heading of this section is "Operation of Wastewater Lift Stations". Many stations can be operated automatically. The frequency of visits to a station depends on the equipment and station conditions. If a lift station overflows after five minutes of down time, this station may require an operator on duty at all times. The remainder of this section outlines what should be done to maintain the operational capabilities of a lift station.

7.431 Station Sign-in Log

Every lift station should have a sign-in log (Figure 7.12). The larger the operating agency, the more important a sign-in log becomes. Everyone who enters the station must sign in and log time of arrival and departure. This rule includes managers, supervisors and operation and maintenance workers. This practice reduces the number of mysterious changes in station operation such as pumps turned off, control system changes, station doors or gates left unlocked, and provides a method for reaching the appropriate person when corrective instructions need to be issued. The sign-in log produces a higher reliability factor in worker performance because workers do not wish to sign their name to a log at a given time indicating that they had made a station visit and a few minutes after their departure have a station fail because they had neglected a minor or major item. The station's sign-in log is kept inside the station on a small shelf or cabinet with the station book. When the last space is used on the sign-in sheet, that person or crew turns the sheet into the agency office to be filed in the station book maintained at the office. New sign-in sheets are kept in the station as part of the preventive maintenance schedule. Some agencies use log books where agency workers sign in and record their activities at the station. The log books are generally maintained at the station for an entire year. Under these conditions, the agency's management may not see these logs and may not be kept informed of station problems and conditions.

7.432 The Station Book

The station book is a loose leaf binder so that changes in the contents can easily be made, thus keeping the station's book up to date. The lift station book should contain the following information:

1. Station identification number.

   Most lift stations are given a name, such as "River Side" or "Park Road". In larger agencies and with the use of computer systems for cost accounting, stations are usually given a code consisting of letters and numbers (RS-25) for identification. This identification code must be used by operating and maintenance workers (see Section 7.6, Record Keeping).

PUMP STATION VISITORS LOG

DATE	IN	OUT	NAME	DATE	IN	OUT	NAME

Fig. 7.12. Station sign-in log

2. Map showing important facilities.

   This map should show location of lift station and force main, including valves, manholes, and discharge point of station force main. Other important features such as access route and other utilities are helpful.

3. Station description.

   This is a brief general description of the lift station and includes type, pump layout, control system and auxiliary systems.

4. Equipment data sheets.

   Detailed equipment data sheets that were completed during the lift station inspection after completion of construction are important. These sheets should contain name plate data and equipment operating characteristics.

5. Safety instructions.

   Station safety instructions for working in the station and on its equipment are included in the book. These instructions must spell out specific hazards encountered in this specific lift station.

6. Emergency conditions.

   Action to be taken when an emergency occurs must be clearly outlined.

SAFETY INSTRUCTIONS

Emergency conditions include:

a. Power failure.

b. Stoppage of inlet line.

c. Simultaneous failure of pumps.

d. Flooding of dry pit.

Critical time until homes or streets are flooded must be included. If auxiliary power generators are not part of the lift station, directions for obtaining one of adequate size and the minimum size should be included in the station book. Also included are procedures to electrically isolate the lift station and to connect a portable generator. If the station must be by-passed, the location of manholes for pump suction and discharge pipes, length and size of pipe required, and size of pump needed to pump around the station until repairs can be made must be in the station book.

7. Station preventive maintenance schedule.

The lift station preventive maintenance schedule should contain every piece of station equipment and include the following information:

a. Task description.

b. Frequency each task is to be performed.

c. If isolation of equipment is required.

d. Maintenance and/or overhaul instructions or number of paragraph containing instructions that apply to that station equipment or maintenance function which are scheduled for that visit.

Development of the station book is not any easy job and the book is not prepared overnight. The book is never completed, because it must be updated and revised due to changing flow conditions, equipment changes and modifications, and continuous attempts to improve operating and preventive maintenance programs.

When your first station book has been prepared, the chore becomes much easier for the next station, because most of the preventive maintenance and overhaul descriptions have been prepared for common equipment and only new equipment that is not in the program requires the development of maintenance procedures. The procedure described in this section has been developed over the past ten years and is continuously being expanded and improved.

7.433 Operation and Maintenance Duties

See Section 7.5, Lift Station Maintenance.

QUESTIONS

7.4I What are the types of significant lift station visits?

7.4J How can the number of responses to lift station alarms or emergency conditions be minimized?

7.4K Why should lift stations have a sign-in log?

7.4L What information is contained in the Station Book?

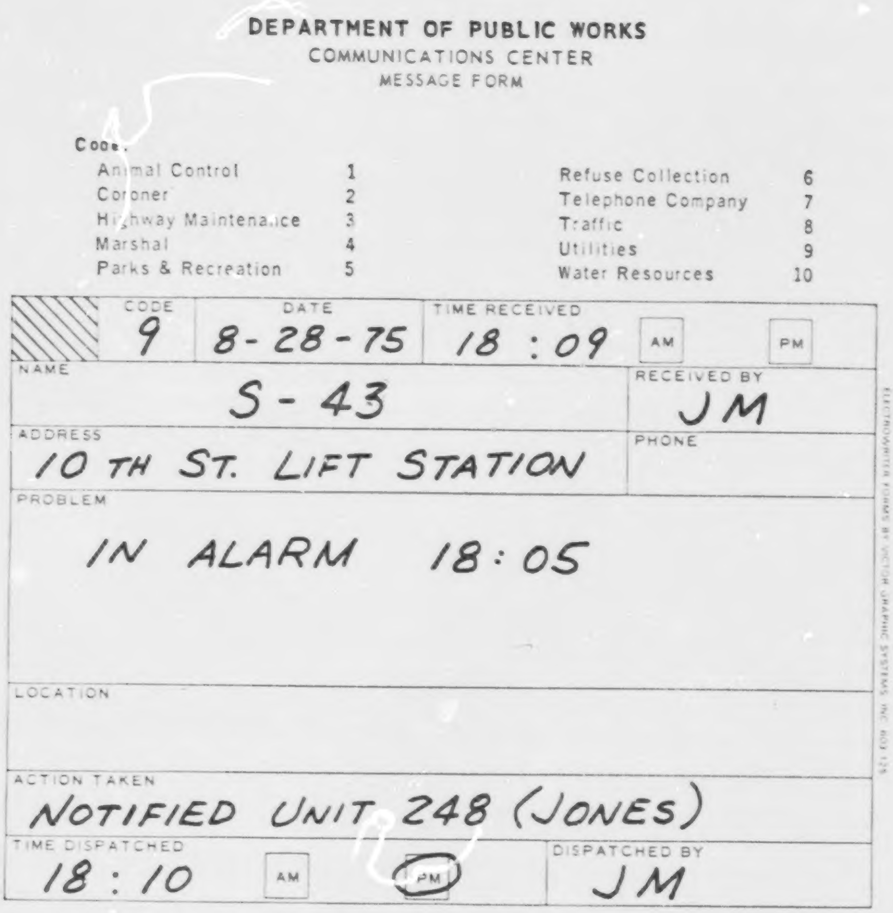
7.434 Responding to Station Alarms

Only a few agencies can afford or use telemetry systems that provide a dial or a meter with numbers that indicate the piece of equipment and nature of the problem in a remote lift station. Many agencies use telemetry alarm systems that transmit one signal that indicates either the lift station is operational or it needs to be visited. The signal is received at a facility that is manned twenty-four hours a day. In many cities this is the local police department or emergency dispatch center. When the station has a failure, the alarm is transmitted usually through leased phone lines to the manned center where a control panel will have an indicator light for the station that goes on when a problem develops. When the light goes on, a horn or some other type of noisy alarm will sound also. When trouble is indicated, the dispatcher notifies the workers on duty by phone or radio of the station identification number. The dispatcher must record on an appropriate log sheet the time and identification number of the station that sent the alarm signal. The time and name of the worker notified must be recorded too (see Figure 7.13).

Usually during off-duty hours, the worker notified by the dispatcher picks up the other worker on the crew with an agency repair vehicle enroute to the problem lift station. When this emergency crew arrives at the lift station, the dispatcher should be notified and given an estimate of when the crew will call back in again. This procedure notifies the dispatcher that the crew has arrived at the lift station and protects the crew in case a serious injury occurs and they are unable to contact the dispatcher. If the crew does not call in again and the dispatcher cannot contact the crew, rescue operations can be started. During stormy and adverse weather conditions and especially at night, crews should be very cautious. Overhead power lines must be inspected BEFORE attempting to open the gates of a lift station. Fallen power lines across a chain link fence could electrocute a person trying to open a gate. When an emergency crew attempts to locate the cause of an alarm, they must inspect the station in the following sequence (also see Section 7.435, Typical Lift Station Problems):

1. Power supply to station.

   If lack of power supply to the station is the problem, the control center dispatcher should be notified by radio to request power company assistance in restoring power to the station. Dispatcher should determine estimated time of arrival of power company crew and then notify the field



DEPARTMENT OF PUBLIC WORKS
COMMUNICATIONS CENTER
MESSAGE FORM

Code:

Animal Control	1	Refuse Collection	6
Coroner	2	Telephone Company	7
Highway Maintenance	3	Traffic	8
Marshal	4	Utilities	9
Parks & Recreation	5	Water Resources	10

CODE: 9
DATE: 8-28-75
TIME RECEIVED: 18:09 ☐ AM ☐ PM
NAME: S-43
RECEIVED BY: JM
ADDRESS: 10 TH ST. LIFT STATION
PHONE:
PROBLEM: IN ALARM 18:05
LOCATION:
ACTION TAKEN: NOTIFIED UNIT 248 (JONES)
TIME DISPATCHED: 18:10 AM [✓ PM]
DISPATCHED BY: JM

ELECTROWRITER FORMS BY VICTOR GRAPHIC SYSTEMS INC 603 125

Fig. 7.13. Typical dispatcher's record

crew. Since lift stations are essential to the community's welfare, power companies place a high priority in restoring service. Some power companies provide special phone numbers for critical utility agencies to use in emergencies to contact their dispatchers in order to restore power as soon as possible to the area where the station is located.

2. Open access to dry well side of station and inspect:

   a. Interior lighting.

   b. Operation of ventilation equipment.

   If the interior lighting in the station is out, use flashlights from the repair truck.

   If the ventilation equipment is off, measure the atmosphere in the lift station and work areas for sufficient oxygen and the presence of explosive and toxic gases. Continue to test the atmosphere in the station until the ventilation equipment has been returned to operation for at least 30 minutes.

   If during the test of the station atmosphere the gas detection meter indicates an adverse condition, the crew must leave the station dry well and ventilate the dry well area with a portable blower. If the station must be entered to correct a serious problem, additional help must be requested. Also needed will be a safety harness and self-contained breathing equipment for reentry to the station under hazardous conditions.

3. Station well pit areas.

   Examine this area carefully to be sure that all levels of the dry well area are not flooded BEFORE restoring high voltage power to operating equipment if the power is out.

If electrical motors are flooded and/or will not start, open main power switches to lower area electrical circuits. Request help in setting up emergency pumping equipment. Locate and repair leak to dry pit. Pump the water out of the dry pit with portable pumps. Conduct electrical megger checks (see Chapter 8, Section 8.23, Tools, Meters and Testers) on electrical circuits and motors that were flooded to make sure they can be operated, or they must be removed and repaired.

4. Motor control center and power panel.

If the dry well area is not flooded and equipment looks normal (no broken pump shafts, pumps not rotating backwards, check valves closed and seated), then return to the motor control center and power panel.

NOTE. In some lift stations, full power may be restored to all operating equipment at one time. In other stations, especially where large pumps are used, the equipment should be put back on line one unit at a time.

The station book should have the proper starting sequence for all of the station equipment. A good practice is to open equipment breakers and bring the station back on line by starting one unit at a time. A suggested starting sequence is as follows:

a. Station lights.

b. Station ventilation equipment.

c. Station sump pumps.

d. Station control system (air compressors).

e. Essential station auxiliary system (water wells and hydraulic system pumps).

f. Station last pump to start.

g. Station second pump.

h. Station lead pump.

i. All station systems.

As each piece of equipment is restored to service it should be inspected for proper operation, lubrication, and if appropriate, operating pressures and flow rates. The station book should indicate the operating ranges of the equipment.

The reason for bringing the last pump on first, the second pump next, and the lead pump last is that this procedure provides each unit with the opportunity to operate and to be inspected before the wet well level returns to normal levels. If the lead pump is started first, the wet well level may fall quickly; and by the time the crew is ready to test run the last pump, the wet well level is too low for automatic operation of the pump. The pump may be inspected in the manual mode of operation, but this does not guarantee it will function in the automatic sequence.

5. Wet well.

If the wet well is flooded and has inlet gates, the gates should be closed or throttled in order to store wastewater in the gravity portion of the collection system until the wastewater level in the wet well can be restored to normal elevations. The station book should list the procedure for closing the inlet gates and specify the critical time the gates can remain closed before damage will result from flooding.

6. After alarm condition has been corrected.

Before the crew departs from the station, they must make sure that all equipment is functioning properly or that damaged equipment is isolated and the station will perform until repairs are made. The following tasks should be completed before leaving the station:

a. Station restored to service.

b. All equipment inspected.

c. Station problem and correction recorded in station book along with identification of crew doing repairs.

   e. Contact dispatcher to verify that alarm condition is cleared from telemetry alarm panel.

7. Report.

   Complete a report form listing crew members, vehicle and equipment numbers, time dispatched, time of arrival at station, work performed, and time of departure from station.

8. Secure lift station.

   Lock lift station and yard gates. Contact dispatcher for next assignment.

When a crew responds to a lift station alarm, the worst possible conditions should be expected. Extreme caution must be exercised by the crew for their own safety, as well as for protection of the equipment and the station. Any number of serious problems may be encountered from downed power lines and/or flooding to broken pipes, valves, or pump shafts. Chlorine leaks can develop if chlorine is applied at the lift station. A coiled rattlesnake on the third step down to the lower pump room is a possible hazard in some areas.

7.435 Typical Lift Station Problems

Lift station problems may be listed in the following four categories:

1. Power
   a. Power failures.
   b. Electrical circuit failures.
      1) Thermal overloads tripped.
      2) Fuses blown.
      3) Relays burned out.
   c. Motors burned out.

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2. Control systems
    a. Telemetry system failure.
    b. Wet well controller.
        1) Float type
            a) Float stuck in stilling well.
            b) Float line broken.
            c) Power off and cam overrode stops.
            d) Mercury switches failed.
        2) Bubbler type
            a) Air compressor failed.
            b) Bubbler line plugged or restricted.
            c) Leak in air piping system.
            d) Diaphragm ruptured.
            e) Mercury switches failed.
            f) Condensed water in air lines.
            g) Bubbler line broken off in wet well.
        3) Electrode systems
            a) Short in electrode leads.
            b) Electrodes coated with grease or rags.
            c) Electrodes tangled when wet well changes levels.
        4) Seal trode units.
            a) Bulb ruptured.
            b) Electrolyte leaked out.
            c) Short in electrode leads.

3. Pumping systems
    a. Pump impeller plugged with rags or sticks.
    b. Pump suction blocked.
    c. Check valve stuck open or flap broken from shaft.
    d. Pump drive shaft from motor broken.
    e. Failure of packing gland or seal water supply.
    f. Pump air or gas bound.

4. Structures
    a. Grit deposits in wet well.
    b. Grease and floating debris in wet well.
    c. Force main restricted or plugged.

Most of these problems can be prevented through a good preventive maintenance program.

QUESTIONS

7.4M How is an alarm situation transmitted from a lift station to a dispatcher at a control center?

7.4N Why should an emergency crew at a lift station notify the dispatcher when they will call in again?

7.4O Why should overhead power lines be inspected by emergency crews upon arrival at a lift station?

7.4P What are the major categories of lift station problems?

END OF LESSON 4 OF 5 ON LIFT STATIONS

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 7. LIFT STATIONS

(Lesson 4 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 3.

17. What action would you take if a lift station failed and the wastewater in the collection system was rising rapidly?

18. How would you determine the frequency of visits to a lift station?

19. Discuss the advantages and limitations of daily versus weekly to monthly visits to lift stations.

20. How would you respond to a lift station alarm failure and how would you attempt to locate or identify the cause of the failure?

21. What would you do during a lift station visit (what items should be inspected)?

22. What types of books or records should be kept in a lift station? Why?

23. What safety precautions would you take BEFORE attempting to determine the cause of a lift station failure?

24. What kinds of problems or failures can occur in lift stations?

CHAPTER 7. LIFT STATIONS

(Lesson 5 of 5 Lessons)

7.5 LIFT STATION MAINTENANCE

Chapter 8 of this manual describes equipment maintenance procedures. The intent of this section is to describe how to establish a maintenance program and a frequency schedule for lift stations. The maintenance program consists of two major parts:

1. Scheduling the work

   Necessary work must be scheduled in advance and must include items that must be performed during a given time period.

2. Performing the work

   Maintenance work must be performed in a specific manner. Every task must be done the same way by every worker.

Both scheduling and performing are important, but the development of a schedule is the most difficult job. Insuring consistent procedures for performing the work is accomplished by providing the workers with written instructions, proper training, necessary tools and evaluation of completed work by supervisors.

7.51 Scheduling Maintenance

Preparation of a lift station maintenance program requires consideration of three important factors:

1. Recommendations of equipment manufacturers.
2. Requirements of lift station.
3. Knowledge previously gained from experience by the operating agency.

7.511 Recommendations of Equipment Manufacturers

Equipment manufacturers provide maintenance and overhaul recommendations for each piece of equipment they install in a lift station. Usually this information is contained in a convenient binder or manual. Information includes frequency of oil changes and lubrication of bearings, types of lubricants, operating temperature ranges, pressures, flow rates, and disassembly procedures for specific equipment maintenance or parts replacement.

During the first year of operation of new equipment, the manufacturers' recommendations must be closely followed to maintain equipment warranties. The equipment maintenance schedule is developed by listing all of the manufacturers' recommendations in sequence according to time periods, such as daily (D), weekly (W), monthly (M), quarterly (Q), semiannually (SA), and annually (A) according to when these functions or tasks are to be performed.

When all of the equipment in the station and the frequency of each maintenance task has been tabulated, then the procedures for performing the tasks should be indexed. If you do not have a standard procedure, refer to the manufacturers' recommendations. Many tasks follow the same procedure regardless of the manufacturer of the equipment. For example, adjustment of packing glands, lubriflushing motor and pump bearings, or alignment of drive couplings usually follow the same procedures, even though the tolerance specifications may be different.

7.512 Lift Station Requirements

Each individual lift station may have different requirements. These differences result from the design and location of the station. The items listed here are the tasks that are required to be performed at given frequencies to keep the station operating. These items should be developed primarily from station operating experience and should be reevaluated annually by field workers, supervisors and management. Reevaluation includes changes in frequency of tasks, operational methods, or lift station revisions or redesign in order to increase station reliability and reduce station failures, alarms and crew work loads.

For example, let's examine the situation where a lift station uses a bar screen, a pump operation control system using a stilling well and float, and the lift station is serving a community with several restaurants which produce an excessive grease load on the station. These conditions cause the station's maintenance demands to be higher than necessary because of the following conditions:

1. The bar screen should be cleaned daily or at least two or three times a week.

2. Grease will create operational problems with the float travel in the stilling well. Hosing and flushing of the stilling well will be required once or twice a week.

3. The wet well will have to be cleaned quarterly instead of annually due to the excessive grease. Clean the wet well walls manually, or use a high velocity cleaner to wash down the wet well walls to prevent grease build up and the generation of hydrogen sulfide. If the grease is not thoroughly removed regularly, the wet well concrete walls will deteriorate and could require patching and protective coatings within five years.

What kinds of alternatives or choices are available? You may not have any and may be forced to schedule the frequent visits to this particular lift station. Or you may have some of the following options:

1. Remove the bar screen and allow the station to operate without it. If piping system or pump starts plugging, the bar screen can be replaced. Hopefully the station will operate without problems after the bar screen is removed.

2. Enforce the local sewer-use ordinance and have the discharger remove the grease at the source and thus prevent the grease from entering the collection system.

3. Record each station alarm and the cause of the failure. Estimate the cost of labor, equipment and materials to correct each failure. Determine the best solution by comparing costs of repairs with cost of a more frequent and extensive maintenance program and possibly more alarm calls. Consideration also must be given to your objectives, such as reducing stoppages and odor problems.

Remember that flows usually increase in the future and wastewater characteristics also change. In many cases maintenance requirements of wet wells and force mains are greater on new lift stations handling low flows because detention times in wet wells and force mains can become very long. When flows through a new lift station increase, conditions may improve and the frequency of performing certain maintenance tasks can and should be reduced. Field crews should be able to make important contributions to decisions regarding the frequency and types of maintenance tasks required by a lift station. These crews are familiar with the station, notice changing conditions, and are capable of comparing conditions and operational characteristics with other lift stations.

7.513 Knowledge Gained from Experience

A very important factor in maintenance scheduling is the knowledge and experience gained by an agency regarding how to deal with local conditions, ability of workers to perform tasks and reliability of existing equipment. The major problem with applying knowledge and experience is that occasionally procedures other than those recommended by the manufacturer appear better. Remember that the manufacturer prepared the manual for use throughout the world and not for your specific conditions and problems. Perhaps the recommended lubricant will not perform satisfactorily due to high or low temperatures in your area. Dust conditions or humidity may require equipment protection filters to be changed at twice the recommended frequency or possibly the filter life can be extended three months longer than recommended. If lift station wet wells only can be safely cleaned in July and August, don't schedule cleaning during February when there is three feet of snow on the ground and the temperatures are below freezing.

7.52 The Actual Maintenance Schedule

The supplement to this chapter consists of pages from a typical lift station (identification code S-14). The purpose of this supplement is to illustrate a preventive maintenance program in a station book. This lift station is visited once a month for scheduled maintenance.

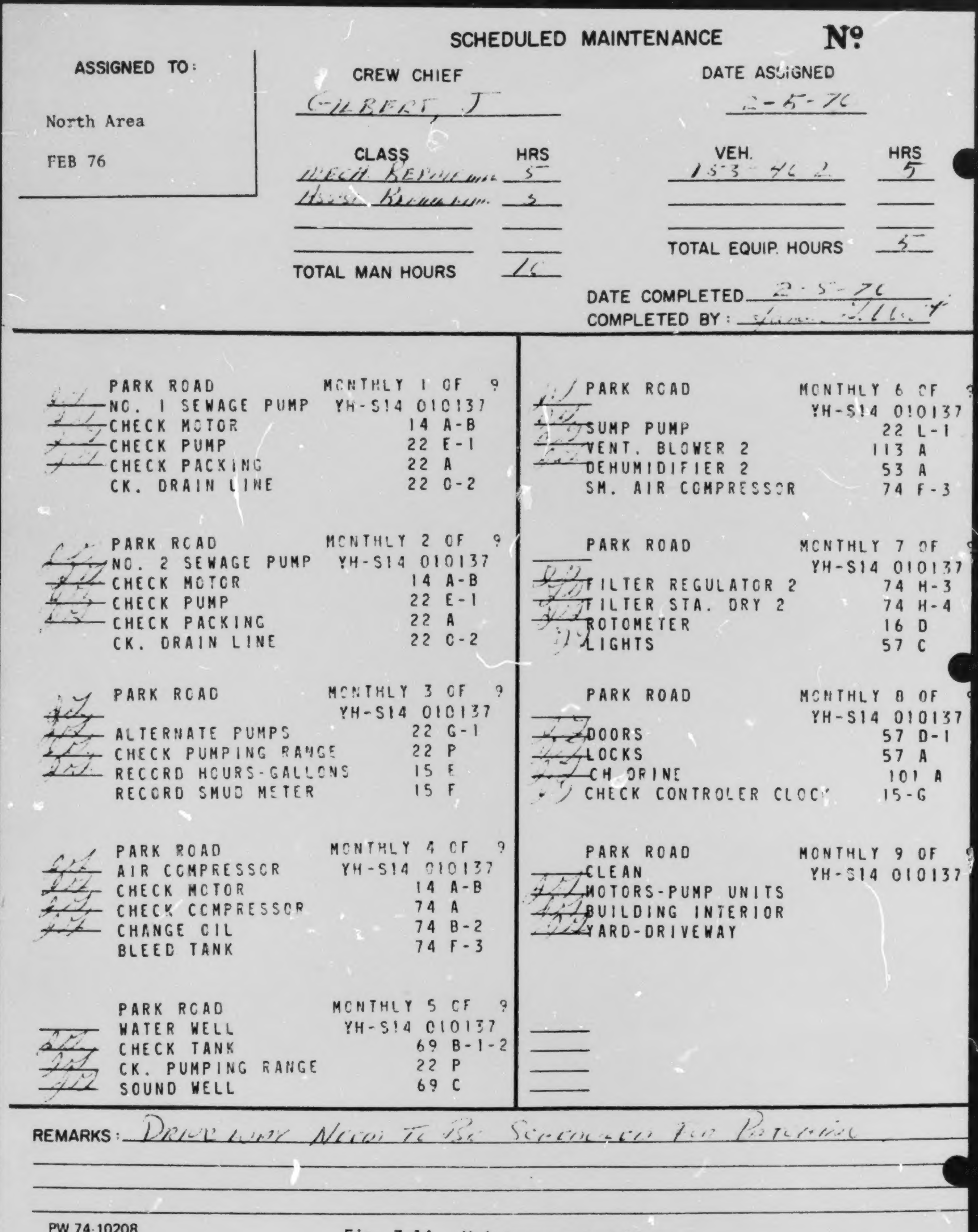
7.521 Crew Notification of Required Maintenance

Once the preventive maintenance is established, there must be a procedure that notifies a crew to perform the required maintenance at the station. There also must be a method of recording when the work is completed by field crews. This information should be checked off against the scheduled work and filed in the lift station book in the main office. If maintenance items are overlooked or not performed, they must be rescheduled and completed.

One method of insuring that work gets completed is by the use of a form such as the one shown in Figure 7.14. This form has a hard copy and two soft copies. The forms are produced each month and one month before the tasks are scheduled to be performed by the agency office staff using an addressograph machine. Every lift station maintenance function is on a separate addressograph plate that is coded to a specific time schedule or interval - weekly, monthly, quarterly, semi-annually, annually, two years and five years. The forms are produced by the addressograph machine with the maintenance functions that must be performed during each month at each facility as shown in Figure 7.14.

The top soft copy of the form is retained in the office with a soft and hard copy going to the supervisors of the field crews. The supervisors assign the maintenance jobs required at each lift station to the field crews who do the work. The form contains the tasks to be performed and the sections in the maintenance and overhaul manual where the task directions and instructions are located. The maintenance and overhaul manual is developed from the manufacturers' instructions and the operating agency's actual experience in maintaining and overhauling the various types of equipment.

When new stations are placed in service, the equipment maintenance procedures are obtained from the appropriate paragraphs in the existing maintenance and overhaul manuals. If new equipment requires different maintenance items or procedures than those already in the existing manual, new instructions are prepared and inserted in the station book and in the field crews' maintenance and overhaul manuals. When a specific maintenance item or job is scheduled, the form (Figure 7.14) will show the section of the maintenance and overhaul manual where the directions are located that specify how to perform the scheduled work.



SCHEDULED MAINTENANCE №

ASSIGNED TO:

North Area

FEB 76

CREW CHIEF Gilbert, J

DATE ASSIGNED 2-5-76

CLASS	HRS
Mech. Repairman	5
Asst. Repairman	5
TOTAL MAN HOURS	10

VEH.	HRS
153-46 2	5
TOTAL EQUIP. HOURS	5

DATE COMPLETED 2-5-76

COMPLETED BY:

PARK ROAD	MONTHLY 1 OF 9
NO. 1 SEWAGE PUMP	YH-S14 010137
CHECK MOTOR	14 A-B
CHECK PUMP	22 E-1
CHECK PACKING	22 A
CK. DRAIN LINE	22 O-2

PARK ROAD	MONTHLY 2 OF 9
NO. 2 SEWAGE PUMP	YH-S14 010137
CHECK MOTOR	14 A-B
CHECK PUMP	22 E-1
CHECK PACKING	22 A
CK. DRAIN LINE	22 O-2

PARK ROAD	MONTHLY 3 OF 9
	YH-S14 010137
ALTERNATE PUMPS	22 G-1
CHECK PUMPING RANGE	22 P
RECORD HOURS-GALLONS	15 E
RECORD SMUD METER	15 F

PARK ROAD	MONTHLY 4 OF 9
AIR COMPRESSOR	YH-S14 010137
CHECK MOTOR	14 A-B
CHECK COMPRESSOR	74 A
CHANGE OIL	74 B-2
BLEED TANK	74 F-3

PARK ROAD	MONTHLY 5 OF 9
WATER WELL	YH-S14 010137
CHECK TANK	69 B-1-2
CK. PUMPING RANGE	22 P
SOUND WELL	69 C

PARK ROAD	MONTHLY 6 OF
	YH-S14 010137
SUMP PUMP	22 L-1
VENT. BLOWER 2	113 A
DEHUMIDIFIER 2	53 A
SM. AIR COMPRESSOR	74 F-3

PARK ROAD	MONTHLY 7 OF
	YH-S14 010137
FILTER REGULATOR 2	74 H-3
FILTER STA. DRY 2	74 H-4
ROTOMETER	16 D
LIGHTS	57 C

PARK ROAD	MONTHLY 8 OF
	YH-S14 010137
DOORS	57 D-1
LOCKS	57 A
CHLORINE	101 A
CHECK CONTROLER CLOCK	15-G

PARK ROAD	MONTHLY 9 OF
CLEAN	YH-S14 010137
MOTORS-PUMP UNITS	
BUILDING INTERIOR	
YARD-DRIVEWAY	

REMARKS: Drive way Needs To Be Screened For Parking

PW 74-10208

Fig. 7.14. Maintenance task forms

7.522 Recording Completed Work

When each task is completed, the crew leader signs it off. When the work has been completed and the form filled out, it is returned to the office where it is matched with the cover copy. A match-up of work required with work completed indicates that the scheduled work was done. On the bottom of the form is an area for comments so that if a field crew finds a discrepancy or a pending problem, it is noted and brought to the attention of a supervisor for corrective action.

Not shown on the station book are preventive maintenance jobs scheduled for two to five-year intervals. These jobs include equipment overhauls and lift station painting.

QUESTIONS

7.5A What are the two major parts of a maintenance program?

7.5B Why should equipment manufacturers' recommendations be followed, especially during the first year?

7.5C Why are maintenance requirements sometimes greater for new lift stations with low flows than with older stations with greater flows?

7.5D Why should field crews be allowed to contribute to decisions regarding the frequency and types of maintenance tasks required by a lift station?

7.5E Why should a form showing work completed be compared with the work assignment?

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7.6 RECORD KEEPING

7.61 Filing of Records

Records are an important part of a lift station operation and maintenance program. They should be filed at the agency's main office. Records left in the lift station are of little value to supervisors or managers. Frequently records left in lift stations get lost or misplaced. Active records (this year) should be kept in the office copy of the station book. This procedure keeps all information at one source. At the end of each operating year or the end of a designated period selected by the agency, the past year's operational and maintenance records are removed from the station book and placed in a station file. This method keeps the station book at the office from becoming too bulky and keeps only pertinent data in the book for the station's operation and maintenance programs.

7.62 Cost Records

Records maintained on each lift station should show at least the costs of operating and maintaining the facility. The costs include the following:

1. Electrical power cost.
2. Fuel costs such as gasoline, diesel, natural or bottled gas.
3. Operational and maintenance costs on basis of labor, vehicles, equipment and supplies.
4. Scheduled preventive maintenance and repair costs on basis of labor, parts, shop expenses, vehicles, tool and equipment rental, paint, lubricants and other supplies.
5. Unscheduled repair costs, including responding to the station telemetry alarms, power failures and other problems that require a visit to the station that was not regularly scheduled.

6. Repair costs to station caused by vandalism or accidents. Record whether or not the costs of the repairs were recovered from individuals who caused the damage.

Record all goods received. A simple and convenient log sheet is as follows:

Date Goods Received	Order Number	Description of Goods	Cost	Date Bill Received

When a bill is received, be sure that the goods were received and that the order is complete before paying the bill. Sometimes orders are delivered that are not complete; and when a bill arrives six months after the goods were received, it can be difficult to remember if the order was complete.

By keeping accurate cost records, these costs for operating and maintaining the station provide the information needed to prepare next year's annual budget. Cost data on a lift station may be kept in the office of a supervisor where the supervisor is expected to maintain up to date records or the information may be recorded on forms supplied by the agency's accounting division.

7.63 Station Identification Number

Auditors and computer people seem to delight in using long strings of numbers and letters for identification purposes. They cannot accept obvious descriptive names such as "Park Road" or "Riverside" for lift stations. By using letters and numbers, they describe the "Park Road" lift station as "L14". "L" indicates lift and 14 is the number assigned to the Park Road facility. Riverside lift station may be identified as L68. Money from the budget to operate the station is assigned a work authorization number so that L14 becomes L14-010691 and Riverside is L68-011274. This code or designation only indicates at which facility and when the money is available. By adding an activity code, you can identify how the money is spent. For example, a typical list of activity codes is as follows:

GX = Operations

YH = Scheduled preventive maintenance

YZ = Unscheduled repairs

AA = Responding to telemetry alarms or emergency conditions

PE = Electrical power charges

PD = Purchase of diesel fuel

PN = Purchase of natural gas

PG = Purchase of gasoline

PC = Purchase of chlorine

XC = Delivery of chlorine

PC
PG
YH
PE
GX
XC
YZ
PD
PN
AA

Depending upon the system and agency, the activity code list may consist of a hundred or more items. A list this long can become a bother, if not confusing to field workers. If the proper identification code is not used by field workers, then the accounting system is of little use because one station may be charged with costs from another station. Therefore, any agency wishing to use a computer accounting system effectively must use a simple system that field workers understand and use.

If a crew is making a visit to the Park Road lift station for an operational inspection, they would record their time as:

1.80 hours GX - L14-01069

If another crew was performing scheduled preventive maintenance at the Riverside station, they would record their time as:

6.50 hours YH - L68-011274

Computer systems can become very complex, depending on the size of agency, information desired from the computer, and number of agencies using the computer. The computer can provide printouts at regular frequencies that show data on costs for manpower, energy, equipment, materials, parts, lubricants and supplies. This information goes to a supervisor who must wade through a stack of papers to determine if the operation and maintenance programs are effective and are not overrunning the budget.

7.64 Other Records

Records other than cost data that are important include:

7.641 Preventive Maintenance Schedule for Lift Stations

The equipment and preventive maintenance schedule for tasks to be performed on a monthly, quarterly, semiannually and annual basis must be properly identified. When this work has been completed and signed off by the appropriate crews, the forms should be filed in the station book at the office.

7.642 Unscheduled Work Order Requests

A report form for unscheduled work shows the type of unscheduled work, why it was performed, and the costs, including labor, equipment and materials. Also the form should indicate where materials were bought and where used to perform the job or repairs.

7.643 Modifications Made to the Station or Force Main

All drawings and plans must be kept up to date to facilitate future work and to evaluate station performance.

7.644 Written Reports

Especially important are written reports providing details of unusual conditions or repairs made to the lift station. These reports should indicate how repairs were made, time required, unusual conditions encountered, special equipment or materials needed, or additional maintenance scheduling required in case the job needs special attention or must be repeated in the future. Unfortunately we sometimes have to do jobs in the future that are similar and no one is available who remembers exactly how a previous job was done or the problems encountered.

7.645 Operational Data

Important operational data includes flow records, equipment lapsed time meter readings, chlorination rates, and other operating data that may be required by your agency.

7.7 SUMMARY

We hope this chapter has stimulated some thought regarding the operation and maintenance of wastewater lift stations. Our experience has shown that proper design and maintenance are the key to lift station reliability. Lift stations can effectively operate themselves if given the opportunity and care they need.

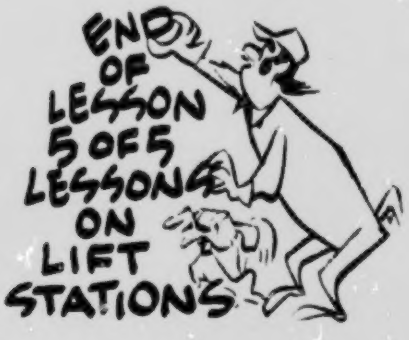
QUESTIONS

7.6A Why should records of a lift station not be filed in the lift station?

7.6B What items should be included in lift station costs?

7.6C Why are activity codes used in accounting or to keep track of lift station costs?

7.6D Why should reports be written detailing how repairs are made?



DISCUSSION AND REVIEW QUESTIONS

CHAPTER 7. LIFT STATIONS

(Lesson 5 of 5 Lessons)

Write the answers to these questions in your notebook before continuing with the objective test on page 7-109. The problem numbering continues from Lesson 4.

25. How would you develop a maintenance schedule for a lift station?

26. Why should a maintenance schedule be reviewed from time to time?

27. If a grease problem develops in a lift station, review the advantages and limitations of the different possible solutions to the problem.

28. What records would you keep of a lift station and how and where would you file them?

29. Why are lift station costs important?

30. What types of written reports should be prepared for lift stations? Why?

SUGGESTED ANSWERS

CHAPTER 7. LIFT STATIONS

7.1A Wastewater is raised or lifted in a lift station by centrifugal pumps or pneumatic ejectors.

7.1B The location of lift stations is influenced by excavation costs to maintain gravity flow. Excavation costs are affected by:

1. Depth of sewer
2. Soil stability and rocks
3. Level of ground water table
4. Location of other utilities, and
5. Surface or overhead structures.

7.1C The two major safety items that must be considered around lift stations are:

1. Safety of operation and maintenance workers
2. Safety of public

7.1D A submersible pump is often installed in a wet well.

7.1E A limitation of a pump installed in a wet well is limited access to the pumping equipment, thus creating a problem when the pump has to be repaired.

7.1F The most desirable operational situation for a wet well is when all the flow and solids that discharge into the wet well from the gravity sewer are lifted to the higher elevation and continue to the wastewater treatment plant without delay.

7.1G Static head is the difference between the water surface elevation in a wet well on the suction side of a pump and the water surface elevation on the discharge side of a pump. Dynamic head is the difference in elevation between the energy grade line on the suction side and the discharge side of the pump. The dynamic head is the static head plus the friction or energy losses that result from water flowing through the pipes, valves and fittings in the lift station.

7.1H Friction losses are caused by water flowing through pipes, valves and fittings in a lift station. The greater the velocity of the flowing water, the greater the friction losses.

7.2A Pumps should not start and stop frequently in lift stations because frequent motor starts cause excessive wear on control circuit relays and motors, tend to cause overheating, and also consume more electrical energy than a motor that operates continuously.

7.2B If a wet well is too large, wastewater is stored too long and solids will settle out. This creates the opportunity for the wastewater to turn anaerobic and produce hydrogen sulfide and odors.

7.2C The main advantage of variable speed pumping equipment is that the pumping rate can be adjusted to meet the inflow rate.

7.2D Bar racks usually are not used in lift stations pumping only domestic and industrial wastewaters because:

1. Screenings are a problem to remove and transport to a disposal site.
2. Pumping units are equipped with open impellers or closed two-port impellers sized to pass most solids found in the collection system.

7.2E Sump pumps in dry wells are used to remove excess water, such as seal water leakage and clean up water.

7.2F When a seal fails on a submersible pump, wastewater can leak into the motor compartment and the unit will shut itself off.

7.2G The two types of float controllers are:

1. Rod attached to floats
2. Steel tape, cable, or rope attached to floats

7.2H If the upper stop on the float rod is raised, the wet well will be pumped farther down, because the float will have to be dropped lower before the pump will shut off.

7.2I Maintenance on a stilling well includes removing grease and debris that hinder or stop the up-and-down movement of the float. Other maintenance or repairs include float attachment line breaking or unwinding from drum sheave and float developing a leak.

7.2J Controls used to start, stop or change pumping rates include float controllers, electrode controllers and pressure sensing controllers.

7.2K Electrical safety regulations must be complied with when using electrode controllers.

7.2L Limitations of electrode controllers include:

1. Rags and debris can wrap around electrodes and alter desired pump start and stop level in a wet well.

2. Grease and/or slime can cover an electrode, thus preventing good conductivity and causing intermittent or unreliable operation.

7.2M Pressure sensing controllers detect pressure changes by measuring the back pressure required to overcome the pressure created by the level of the water above the outlet of the bubbler.

7.2N Problems that can develop using seal trode sensing controllers include:

1. Bulbs can break.
2. Shorts occur in electrode wiring.
3. Bulb life is 3 to 5 years.

7.2O Pressure sensing controllers measure depth of water in a wet well on basis of air pressure or back pressure in the air bubbler line.

7.2P Problems that can develop with pressure sensing controllers include:

1. Air compressor failure.
2. Bubbler blockage, tube breakage, or outlet elevation shifts.
3. Many opportunities for equipment failure.
4. Need for a higher level of training for workers to trouble shoot, repair and keep instruments calibrated.

7.2Q Lift stations should be equipped with at least two pumps to provide continuous operation if one pump fails or requires repairs.

7.2R Each pump must be equipped with a suction and a discharge isolation valve so that the pump can be isolated from the wet well or discharge force main for draining, cleaning, repacking and other maintenance work.

7.2S Pump seal water from a domestic water supply must have an air gap to prevent contamination of the public water supply from back flows.

7.2T Some lift stations have emergency generators so they can continue to operate during power failures.

7.3A Operation and maintenance workers should review prints and specifications of a new lift station before construction to be sure adequate provisions have been made for the station to be easily and properly operated and maintained.

7.3B Accessibility to a lift station is important because workers and equipment need to be able to easily reach the lift station and have room to park vehicles and work.

7.3C Before equipment is installed in a lift station, determine its familiarity to agency, reliability, warranty, guarantees and the operation and maintenance aids that will be provided.

7.3D Prints and specifications should be carefully reviewed before construction and installation because changes are easily made on paper and are much more difficult in the field.

7.3E After a lift station is completed but before it is accepted, it should be inspected by the engineer and the people responsible for its operation and maintenance.

7.3F Information regarding lift station equipment and performance should be filed with a copy in the lift station and a duplicate copy at the agency office.

7.3G Data from initial tests on equipment should be recorded and filed to document that the equipment meets specifications and to show how it performed when installed.

7.3H Problems that may be encountered when cleaning a wet well include slippery floors, inadequate ventilation, cleaning bar rack, disposal of debris, lack of oxygen, explosive gases, and toxic gases.

7.3I Hazards found in confined spaces include lack of oxygen, explosive and toxic gases.

7.3J Hazards encountered in sumps can be reduced by adequate hosing of sludges and slimes on sump floor and ventilation to provide a satisfactory environment.

7.3K When inspecting electrical equipment, start by recording all name plate data.

7.3L When inspecting an electrical circuit or equipment, the main circuit breaker must be locked in the OFF position.

7.3M Extra fuses should be kept at the station so blown fuses can be replaced immediately and equipment down time is minimized.

7.3N The working of the electrical circuits should be learned before the station becomes operational.

7.3O Anti-rotation equipment is used to prevent the pump from rotating in the wrong direction.

7.3P If a universal joint is over lubricated, the seal on the universal will blow and cause failure in a very short time.

7.3Q If an engine's internal alarm system fails, the engine could burn up.

7.3R When changing engine oil, look for metal filings and sludge as indicators of engine condition. Look for water or an oil-water emulsion that indicates water in the wrong place.

7.3S Engines must be inspected thoroughly in an attempt to prevent problems and to learn what to do if problems develop. The jobs of trouble shooting and repairing become easy when there is good data for reference.

7.3T When lubricating the clutch throw-out bearing, lubrication should not be excessive.

7.3U Condensation can form inside an engine when a hot engine cools.

7.3V We must have oil, water and fuel for engine operation.

7.3W Leakage from a packing gland should be approximately one drop per second.

7.3X Teflon packing should not get hot because it will glaze and stop working properly.

7.3Y The minimum pressure for the flushing water on a mechanical seal is 3 to 5 psi above the stuffing box pressure.

7.3Z The first thing to do before operating a lift station is to open any valves on the influent line to fill the sump. The pump suction and discharge valves must be open before the pump is started.

7.3AA The debris left in the sump should be removed to prevent damage to the pump and clogging of pipe lines.

7.3AB Sump level can be determined by:

1. Sump level indicator
2. Visual inspection
3. Action of mercury switches

7.3AC Pump rotation can be determined by noting:

1. If rotation is in direction of arrow on side of pump.
2. If rotation is in direction of volute in centrifugal pumps.
3. Size of flow and discharge pressure.
4. Amperage drawn by pump motor.

7.3AD Yes, all points of operation for all pumps must be inspected.

7.3AE Do not operate any unit if you think it is not functioning properly.

7.3AF All data must be recorded when test operating the station so you have a record of conditions when the station started.

7.4A Nearby streams and rivers can be protected from wastewater when a lift station fails by the use of portable emergency equipment to pump wastewater to a functioning section of the downstream collection system.

7.4B Complaints from the public about a lift station can be minimized if the workers responsible for the lift station maintain it in top operating condition and respond to complaints and questions in a positive and concerned manner. When responding to a complaint, be sure to tell the public what has been done or what will be done to correct the complaint.

7.4C The most important rule that always must be considered when visiting a lift station is SAFETY.

7.4D The frequency of lift station visits depends on the following:

1. Number of stations in community.
2. Type of wastewater being conveyed.
3. Potential damage from storms flooding station.
4. Condition of equipment.
5. Design of facility and equipment installed.
6. Adequacy of preventive maintenance and overhaul program.
7. Type, adequacy, and reliability of telemetry system.
8. Attitude of operating agency towards operation and maintenance.

7.4E Lift station failures include:

1. Electrical power failures
2. Failure of level-sensing or other control equipment
3. Flooded wet wells
4. Plugged pump impellers or lines
5. Overheated and tripped out motor thermals
6. Sump pump off and sumps or dry wells flooded
7. Air or gas bound pump
8. Stuck or blocked check valve
9. Pump control systems not functioning
10. Failure of lift station telemetry system
11. Ventilation fans burned out

7.4F The critical time for a lift station after failure is the time interval before flooding or damage occurs.

7.4G Daily visits to a lift station are required when essential operational and maintenance tasks must be performed on a daily basis to keep the station operable and reliable.

7.4H For a lift station to be visited only from once a week to once a month, the following requirements must be met:

1. Equipment lubrication reservoirs must be large enough.
2. Telemetry of the station must include wet wells, dry well sump pump pit level, power, compressor, check valves and auxiliary equipment.
3. Crews must be able to respond to alarms before flooding or damage occurs.

7.4I There are two types of significant lift station visits:

1. To scheduled routine preventive maintenance upon the equipment and the station.
2. To respond to a lift station alarm or emergency condition to restore the station to operation.

7.4J The number of responses to lift station alarms or emergency conditions can be minimized by a good preventive maintenance program and if the frequency schedule is at the proper intervals with clear duty assignments in writing and completion verified by management.

7.4K Lift stations should have a sign-in log to reduce the number of mysterious changes in station operation such as pumps turned off, control system changes and station doors or gates left unlocked. Also this practice provides a method for reaching the appropriate person when the need arises to issue corrective instructions.

7.4L The Station Book should contain the station identification number, a map showing important facilities, station description, equipment data sheets, safety instructions, responses to emergency conditions and the stations preventive maintenance schedule.

7.4M Alarm situations may be transmitted over leased telephone lines or by a radio signal.

7.4N An emergency crew at a lift station should notify the dispatcher when they will call in again so in case a serious injury occurs and they are unable to contact the dispatcher, rescue operations can be started.

7.4O Overhead power lines should be inspected by emergency crews upon arrival at a lift station because if they are broken, they could come in contact with a chain link fence or other conductor and electrocute a crew member opening a gate.

7.4P The major categories of lift station problems are:

1. Power
2. Control systems
3. Pumping systems
4. Structures

7.5A The two major parts of a maintenance program are:

1. Scheduling the work, and
2. Performing the work.

7.5B Equipment manufacturers' recommendations must be closely followed to maintain equipment warranties.

7.5C Maintenance requirements may be greater on new lift stations handling low flows because detention times in wet wells and force mains can be very long and allow the production of hydrogen sulfide.

7.5D Field crews can make valuable contributions because they are familiar with the station, notice changing conditions, and are capable of comparing conditions and operational characteristics.

7.5E A form showing work completed must be compared with the work assignment to be sure all scheduled work is completed.

7.6A Records should not be filed in a lift station because they can get lost or misplaced. Also they are of little value to supervisors or managers.

7.6B Lift station costs include power, fuel, operation and maintenance (labor, vehicles, equipment and supplies), scheduled preventive maintenance, unscheduled repair costs, responses to alarms and vandalism.

7.6C Activity codes are used to help identify exactly how money is spent on a lift station.

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7.6D Reports should be written detailing how repairs are made so if a similar job must be done in the future, this report can serve as a helpful reference.

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OBJECTIVE TEST

CHAPTER 7. LIFT STATIONS

1. Lift stations are used to lift

    1. Wastewater
    2. Sewer gases
    3. Sewer odors
    4. Sewer pipe
    5. Storm water

2. Lift station location depends on

    1. Diameter of sewer
    2. Level of ground water table
    3. Economic factors
    4. Depth of excavation
    5. Pipe material

3. Important lift station considerations include

    1. Costs
    2. Pumps
    3. Safety
    4. Access
    5. Reliability

4. Flow may be expressed in the following units of measurement

    1. MG/L
    2. MGD
    3. CFS
    4. AC-FT
    5. GPM

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5. Bar racks are undesirable in sanitary wastewater collection systems because

   1. They stop solids from plugging pumps
   2. The screenings must be removed
   3. The screenings cause odors and attract flies
   4. Disposal of the screenings is a problem
   5. Wrong, they are desirable

6. Limitations of float control systems include

   1. Grease and debris enter the stilling well and hinder or stop the movement of the float.
   2. Sensitivity to fluctuations of water surface elevation in wet well.
   3. Float attachment line can break and call for all or none of the pumps to operate.
   4. Floats develop leaks.
   5. Signals activated by floats are easily transmitted to pumps.

7. Limitations of electrode controllers include

   1. Reliable operation
   2. If not properly maintained, pumps may not start and stop when desired
   3. Safe to use
   4. Rags and debris can foul electrodes
   5. Grease or slime can cover electrodes

8. Lift station pumps

   1. Should be capable of pumping spheres at least 2.5 inches in diameter.
   2. Should have suction and discharge isolation valves.
   3. Should have a bottom volute drain.
   4. Should have an air gap in the seal water piping if the water comes from a domestic water supply.
   5. Should always be submersible pumps.

9. Items that should be examined when reviewing lift station prints include:

   1. Warranties
   2. Accessibility
   3. Overhead clearances
   4. Lighting
   5. Layout of pipes and equipment

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10. Items that should be examined when reading lift station specifications include:

    1. Equipment reliability
    2. Proper color coding on pipes
    3. Warranties
    4. Layout
    5. Access

11. After a lift station has been completed, but before it is put in service, the following items should be inspected:

    1. Access for equipment removal
    2. Operating costs
    3. Location of electrical lines
    4. How to remove grit and debris from wet well
    5. Maintenance and overhaul costs

12. The following items should be inspected on new pumps

    1. Direction of rotation
    2. Cavitation
    3. Drive mechanism
    4. Guards on rotating parts
    5. Packing gland or mechanical seal

13. The following items should be inspected when a new lift station is put into operation:

    1. Manpower requirements
    2. Debris in wet well
    3. Wet well level controllers
    4. Valve positions (open or closed)
    5. Corrosion damage

14. Complaints regarding lift stations can be minimized by:

    1. Proper maintenance
    2. By-passing the station
    3. Analyzing causes of complaints and taking corrective action
    4. Good landscaping and maintaining pleasant appearance
    5. Responding to citizen's complaints or questions in a positive and concerned manner

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15. Common types of lift station failures include:

1. Structural or building
2. Power
3. Foundation
4. Controls
5. Pumps

16. Items that should be considered when determining the frequency of visits to lift stations include:

1. Number of stations in the community
2. Type of wastewater
3. Design of facility
4. Adequacy of preventive maintenance and overhaul program
5. Type, adequacy, and reliability of telemetry system

17. Daily visits to lift stations may be undesirable because they:

1. Minimize problems
2. Tend to cause workers to be less critical than less frequent visits
3. Sometimes provide a situation where important maintenance work is postponed until tomorrow
4. Provide workers the opportunity to inspect the equipment every day
5. Allow equipment to be maintained every day

18. Lift stations may be visited at time intervals from once a week up to once a month if:

1. You are lucky, this idea won't work, lift stations must be visited daily
2. The community has only one lift station
3. The equipment lubrication reservoirs are large enough
4. The station has an adequate telemetry system
5. The bar screen keeps plugging with grease

19. Significant types of lift station visits include:

1. Performing scheduled routine preventive maintenance
2. Supervisors checking to be sure crews are performing assigned duties
3. Giving guided tours
4. Mowing the lawn
5. Responding to lift station alarms

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20. The purpose of a lift station sign-in log is to:

1. Keep track of who visits the lift station
2. Identify who makes changes in station operation
3. Find out who may need corrective instructions
4. Produce a higher reliability factor in worker performance
5. Allow guests to sign their names

21. A lift station Station Book should include:

1. Agency budget
2. Safety instructions
3. Map showing important facilities
4. Responses to emergency conditions
5. Equipment data sheets

22. What items should be inspected when responding to a station alarm at night?

1. Interior lighting
2. Operation of ventilation equipment
3. Dry well
4. Motor control center and power panel
5. Wet well

23. After correcting an alarm situation in a lift station and before leaving the station, the following tasks should be done or checked:

1. Turn ventilation system off
2. Observe wet well and inflow
3. Record problem and correction in station book
4. Contact dispatcher to be sure alarm condition is cleared from telemetry alarm panel
5. Secure lift station

24. When preparing a lift station maintenance program, the following factors should be considered:

1. Knowledge gained from experience
2. Station identification number
3. Recommendations of equipment manufacturers
4. Computer activity codes
5. Requirements of lift station

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25. How can a supervisor be sure scheduled maintenance is completed?

1. Inspect work himself
2. Ask the workers
3. Wait and see if there are any failures
4. Use a form that compares work assigned with work completed
5. Hire someone to inspect completed work

26. Cost records for a lift station should include costs of:

1. Power
2. Operation
3. Living
4. Maintenance
5. Repairs

27. Written reports providing details of unusual conditions or repairs to a lift station should include:

1. Additional maintenance scheduling required
2. How repairs were made
3. Good literary style
4. Special equipment required
5. Review of literature

28. Pumps draw more power starting than during normal operating conditions because:

1. Pipe friction losses are greater
2. Energy is required to get the water moving
3. Check valves have to be pushed open
4. The total dynamic head is greater
5. The motor and pump have to start turning

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Review Questions

29. Precautions that should be taken when operating a high velocity cleaner include:

    1. Not letting the nozzle rotate in one place
    2. Not allowing so much material to build up below the nozzle that it becomes stuck
    3. Not using a porcupine nozzle
    4. Being careful not to "blow toilets"
    5. Being careful not to cause more damage if a sewer appears to be failing

30. Hydrogen sulfide must be controlled because the gas is:

    1. Flammable
    2. Odorless
    3. Toxic
    4. Explosive
    5. Colorless

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22
25
17
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4

SUPPLEMENT TO CHAPTER 7

LIFT STATIONS

A PREVENTIVE MAINTENANCE PROGRAM
for
Park Road Lift Station

NOTE: For another type of operation and maintenance (O & M) manual for a typical lift station, see "Standard Operating Job Procedures (SOJP) No. 3, Pump Stations" from "A Guide for the Development of Standard Operating Job Procedures for Wastewater Treatment Plant Unit Operations," developed by Charles County Community College, La Plata, Maryland, for the Manpower Development Staff, U. S. Environmental Protection Agency, Washington, D. C. 20460, 1973.

EXPLANATION OF SUPPLEMENT

This supplement is intended to serve only as an example of a portion of a typical lift station book. The actual station book for a typical lift station (S-14) consists of two, three-inch thick binders which contain equipment and agency data that are described in this chapter. Material contained in this supplement (starting on page 1) is from Sacramento County's maintenance and overhaul manual. The manual was developed and written by the County and serves 128 separate facilities.

The actual maintenance and overhaul manual contains several hundred pages and prescribes maintenance procedures for equipment in 128 facilities ranging from wastewater lift stations, storm water lift stations, wastewater treatment plants, and domestic water wells and distribution systems. The entire maintenance and overhaul manual is not presented, but only portions that pertain to some of the equipment listed in the typical station (S-14) is presented to illustrate a method used by one agency to accomplish its maintenance program.

The mechanical maintenance field crews that use the maintenance and overhaul manual are skilled workers who perform all work with the exceptions of electrical power services and instrumentation that consists of analog or digital components. This work is performed by other workers qualified with the necessary skills in the electrical and instrumentation fields.

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STATION DESCRIPTION	2
STATION AND FORCE MAIN LOCATION	1

SCHEDULED PREVENTIVE MAINTENANCE - S14

EQUIPMENT	MANUAL REFERENCE	DRAWING	PAGE NO.
AIR COMPRESSOR	1.10	1.10-G	8
Condition Check	1.10-A		10
Oil Change	1.10-B		10
Small Compressor Lube	1.10-F-1		10
Drain Condensation	1.10-F-3		10
Air Filter	1.10-H-2-4		10
Safety Valve	1.10-I		10
Gauge Check	1.10-J		10
BELT	2.02		11
V Belt Check-Adjust	2.02-B		11
BLOWERS-VENTILATION	2.20		12
Removal From Service	2.20		12
Inspection	2.20-A		12
BUILDING MAINTENANCE	2.40		13
Locks	2.40-A		13
Lights	2.40-B		13

SCHEDULED PREVENTIVE MAINTENANCE - S14 (cont'd)

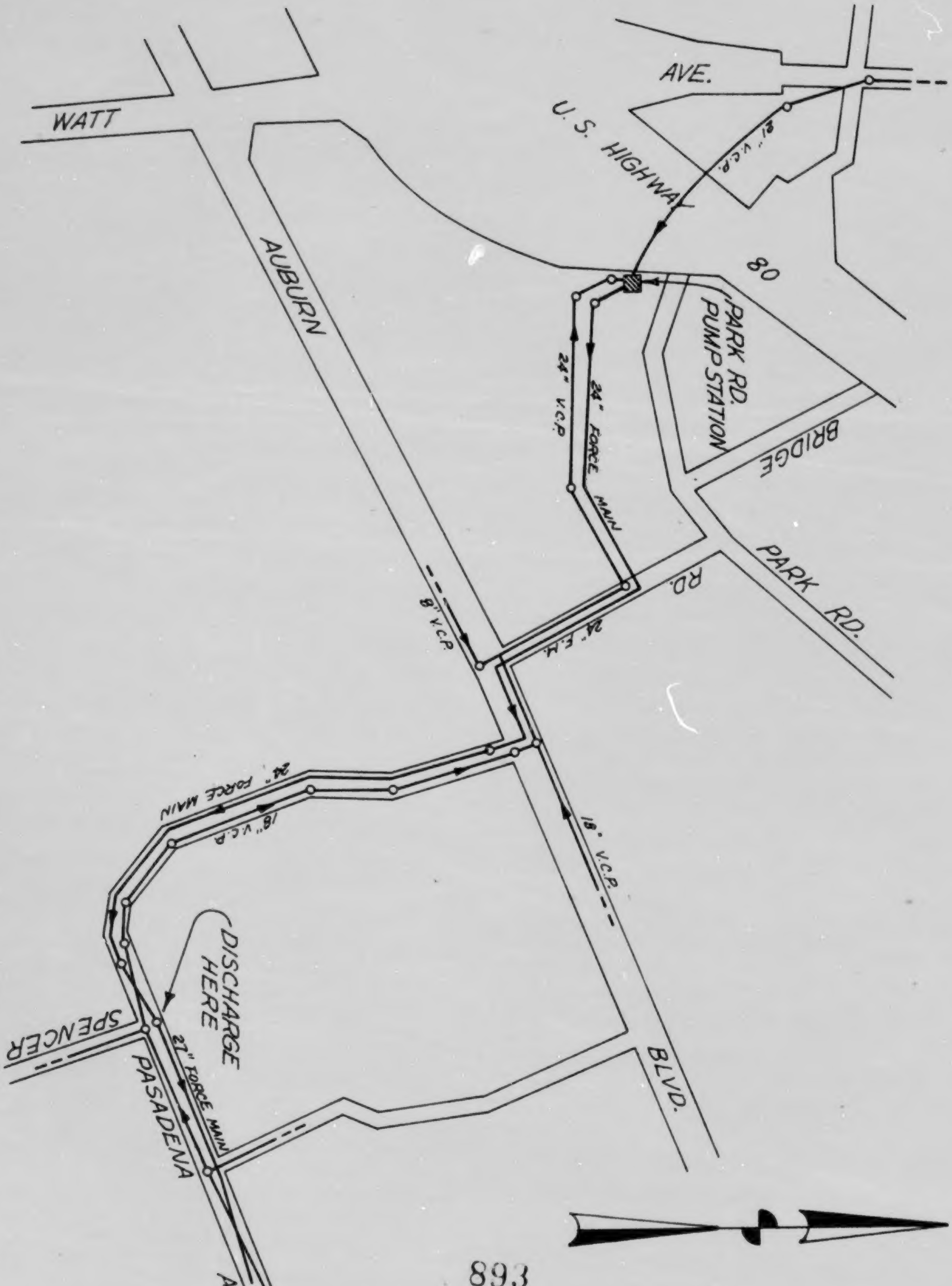
EQUIPMENT	MANUAL REFERENCE	DRAWING	PAGE NO.
BUILDING MAINTENANCE			
Doors	2.40-C		13
Housekeeping	2.40		13
Electrical Prev.-Maintenance	2.40		13
CHLORINATOR	3.20		14
Isolation	3.20-A-1		14
Pressure Reducing Valve	3.20-A-7		14
Check For Leaks	3.20-A-9		14
Valve Check	3.20-A-11		14
Cleaning Chlorinator Body	3.20-A-15		14
Cleaning Valve Seat & Valve Plug	3.20-A-16	3.20-P-Q	14
Cleaning Primary & Secondary Filter	3.20-A-17	3.20-R	15
Meter Tube Cleaning	3.20-A-18	3.20-S	16
CONTROLS-ROTOMETER	3.31	3.31-A	17
Bubble Line Check	3.31-D		17
Manual Purge	3.31-D-1		17
COUPLING	3.40	3.40-C	19
General	3.40-A		18
Check Flexible Coupling	3.40-B		18
Coupling Disassembly	3.40-B-1-2		18
Alignment Procedure	3.40-B-3		18-19
DEHUMIDIFIER	3.50		20
Operational Check	3.50-A		20
Lube And Inspection	3.50-B		20

SCHEDULED PREVENTIVE MAINTENANCE - S14 (cont'd)

EQUIPMENT	MANUAL REFERENCE	DRAWING	PAGE NO.
ELECTRIC MOTORS	6.01	6.01-B-C	21-22
Condition Check	6.01-A		23
Unusual Conditions	6.01-B		23
Lube-Flush Bearings	6.01-C		23
Scope Bearings	6.01-F		23
METERS	6.10		24
Gallons Counter	6.10-J		24
Electrical Power Meter	6.10-K		24
PIT-WET	7.10		25
Inspection	7.10		25
Definition Of Wet Pit	(Foot Note)		25
PUMPS-CENTRIFUGAL	7.20	7.20-A	26
General	7.20		27-28
Packing Glands	7.20-A-B		29
Condition Check	7.20-E-1		29
Operate Pumps Alternately	7.20-G		29
Lubrication	7.20-H-1		29
Water Lube Line	7.20-N		30
Pumping Range	7.20-P		30
PUMPS SUMP	7.20	7.20-C	31
Operation Check	7.20-L-1		32
Inspection	7.20-L-2		32
STRAINERS	7.94		33
Inspection And Cleaning	7.94-A		33
VALVES-AIR RELIEF	8.10		34

SCHEDULED PREVENTIVE MAINTENANCE - S14 (cont'd)

EQUIPMENT	MANUAL REFERENCE	DRAWING	PAGE NO.
VALVES-GATE	8.30	8.30-A	35
Operation	8.30-A		35
Packing Adjustment	8.30-B		35
Packing Lube	8.30-C		35
VALVES-BALL	8.30		36
Operation Check	8.30-D-1		36
Inspect-Clean	8.30-D-2		36
VALVES-GLOBE	8.30-E		36
VALVES-BURIED	8.30		36
Inspect-Lubricator	8.30-F		36
Hydraulic Gate Operator	8.40-C		37
WATER WELLS	9.01		38
Clean-Inspect-Tank	9.01-A		38
Tank Maintenance	9.01-B		38
Standing Water Level	9.01-C-1		39
Sounding Well	9.01-C-2		39


WATT
AVE.
U.S. HIGHWAY
80
21" V.C.P.
AUBURN
BLVD.
PARK RD.
PUMP STATION
BRIDGE
PARK RD.
RD.
24" V.C.P
24" FORCE MAIN
8" V.C.P.
24" F.M.
18" V.C.P.
24" FORCE MAIN
18" V.C.P.
DISCHARGE HERE
SPENCER WA
PASADENA
AVE.
27" FORCE MAIN
6" V.C.P.

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GENERAL DESCRIPTION

1. STATION DESCRIPTION

The design of the Park Road Wastewater Lift Station S-14 includes the following features:

a. A dual centrifugal pump lift system discharging into a common force main.

b. An automatic ampl-speed flow match control system.

c. A chlorine injection system into the discharge flow.

d. A telemeter monitoring system which telemeters to the central office.

2. SAFETY INSTRUCTIONS

a. The station uses 115/440 vac electricity in various applications. Use caution when near wires or connection.

b. Use adopted safety measures when in areas; or working on equipment containing chlorine.

c. Air pressure lines within the station contain pressures up to 60 PSI. Care should be taken to isolate any air operated component before removing it from the system.

d. Working in an enclosed area presents safety hazards to personnel (wet pit). Unless there is a way of constantly testing the station atmosphere, a ventilation blower must operate at all times while the wet pit is occupied. If the main ventilation blower is out of service and work must be performed in an enclosed area, a blower of equivalent capacity must be placed in operation during occupancy of the station. An enclosed area is defined by the State of California, Division of Industrial Safety as: The interior of storm drains, sewers, vaults, utility pipe lines, manholes, and any other structure which is similarly surrounded by confining surfaces so as to permit the accumulation of dangerous gases or vapors.

e. Return all equipment to normal operating condition before leaving the station. Verify that the station lights have been turned off and the door is locked.

f. In the event of station flooding, three workers must be present during maintenance, one in the pit and two above flooded area.

A safety harness and safety line, and at least one explosion proof light must be available during the performance of enclosed area maintenance.

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3. EMERGENCY CONDITIONS

The Park Road Lift Station S-14 will be put out of operation under the following conditions:

a. Power failure.

b. Inlet line stoppage.

c. Simultaneous pump system failure.

d. Station flooding dry pit area.

In the event of an emergency condition whereby the station becomes unoperative due to power failure, an auxiliary generator can be substituted for normal power. This generator must have a minimum capacity output of 400 volts - 135 K.W. to operate one wastewater lift pump and small power demands for station operation.

The isolation of the station from normal power source to operation on emergency generator conditions shall be performed by an electrician.

In the improbable situation the station would have to be bypassed,the following procedure would be used, using an auxiliary pump: The suction line must be placed in manhole 1 and the pump discharge line placed in manhole 2 at the intersection of Pasadena Ave. and Spencer Way, approximately 3,550 ft., i.e. a little under 3/4 of a mile. For these locations, refer to the drawings on page 1.

In order to satisfy the flow demand, it will be necessary to use a 10" portable pump and 10" discharge line. (Pump (10" Jaeger) and hose available at maintenance yard).

MISCELLANEOUS EQUIPMENT - S14

Wastewater Pumps

Packing 3/4" water lube

Lube Line

3/8" line, solenoid, press gauge, 1/4" Foxboro purge meter model NA 1501A scale 1-5 c.p.m. check and gate valve. Strainer screen in main line.

Drain Line - 3/4"

Coupling - Weeds Sur. Flex #14F

Suction - 12" Line

Gate valve - 12" Crane - non rising stem, wheel control.

Discharge 10" Line

Ball valve automatic stop and check control. Bottom coupling - 1026DV2815-10" top coupling 101131. Willamette emergency shut off control size 10. Emergency close switch A540031B. Micro adj. pulse switch #1PD1-2-64 serial 2. 2 mercoid control switches on 3/4" pipes. Leslie strainer.

Control Bubble Line, Air Comp.

Alternation - lead pump manual.

Panel

Wet well level
Hour counters (2)
Fold chart GPM & PSI.
Pump motor control switches (2)
Pump motor tachometers (2)

Force Main

14" line in the station. Foxboro press. Transmitter Model 144B.P. Foxboro filter Regulator type 65-R Magnetic flowmeter on 14" discharge line.

Gate Vale #1

Location across the creek in the rear of the station. Raised manhole cement box outside of manhole with buried valve stem, wrench in the station.

Gate Valve #2

Location on the southeast side of Pasadena Ave. at Auburn Blvd., intersection large manhole cover, small valve stem cover near by. Wrench in station.

Slide Gate

Influent, power failure automatic, manual hydraulic water power norpack compression cylinder, model XDCSS 3/4" water lines, valves, solenoids and Leslie strainer.

Telemeter

Pit high water
Lower floor sump pump failure
Low water pressure
Influent gate
Panel door
Low chlorine pressure

Motor by pass pin outs to relieve alarm signal during intentional motor power shut off for mechanical repair.

PREVENTIVE MAINTENANCE SCHEDULE - S-14

EQUIPMENT	TASK DESCRIPTION	FREQUENCY*	ISOLATION REQUIRED	MAINT./OVERHAUL INST. NO.	PAGE NO.
AIR COMPRESSOR	LUBEFLUSH MOTOR	A	YES	6.01-C	23
AIR COMPRESSOR	SCOPE MOTOR BEARINGS	A	NO	6.01-F	23
AIR COMPRESSOR	SCOPE COMP. BEARINGS	A	NO	6.01-F	23
AIR COMPRESSOR	CHECK BELTS	S/A	YES	2.02-B	11
AIR COMPRESSOR	CHECK GAUGES	S/A	NO	1.10-J	10
AIR COMPRESSOR	CHECK RELIEF VALVE	S/A	NO	1.10-I	10
AIR COMPRESSOR	CLEAN AIR FILTER	S/A	YES	1.10-H-2	10
AIR COMPRESSOR	CHECK MOTOR	M	NO	6.01-A-B	23
AIR COMPRESSOR	CHECK COMPRESSOR	M	NO	1.10	10
AIR COMPRESSOR	CHANGE LUBE OIL	M	YES	1.10-B-2	10
AIR COMPRESSOR	BLEED TANK	M	YES	1.10-F-3	10
AIR COMPRESSOR SMALL	LUBE COMPRESSOR	S/A	YES	1.10-F-1	10
AIR COMPRESSOR SMALL	DRAIN CONDENSATION	M	YES	1.10-F-3	10
VENT BLOWERS (2)	CHECK MOTOR LUBE	A	YES	2.20-A-4-5	12
VENT BLOWERS (2)	CHECK OPERATION	M	NO	2.20-A	12
BUILDING MAINTENANCE	CHECK LOCKS	M	NO	2.40-A	13
BUILDING MAINTENANCE	CHECK LIGHTS	M	NO	2.40-C	13
BUILDING MAINTENANCE	CHECK DOORS	M	NO	2.40-D-1	13
CHLORINATOR	CLEAN VALVE SEAT & PLUG	M	YES	3.20-A-16	14
CHLORINATOR	CLEAN PRIMARY AND SECONDARY FILTER	M	YES	3.20-A-17	15
CHLORINATOR	SHUT DOWN CHLORINATOR	M	YES	3.20-A-1	14
CHLORINATOR	CLEAN METER TUBE	M	YES	3.20-A-18	16
CHLORINATOR	CHECK C.P.R. VALVE	M	YES	3.20-A-7	14
CHLORINATOR	CHECK FOR LEAKS	M	NO	3.20-A-9	14
CHLORINATOR	BODY CLEANING	M	NO	3.20-A-15	14

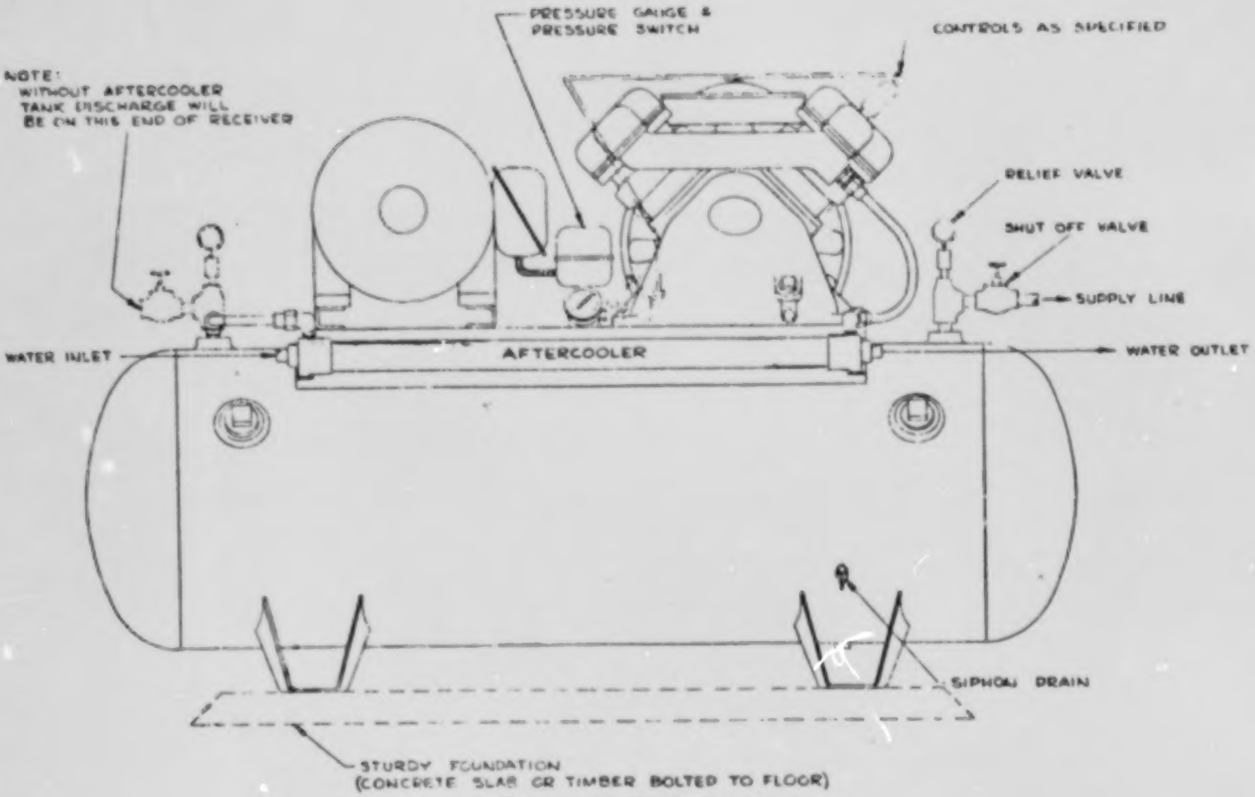
* A - Annually; S/A - Semi-Annually; M - Monthly.

PREVENTIVE MAINTENANCE SCHEDULE - S-14

EQUIPMENT	TASK DESCRIPTION	FREQUENCY	ISOLATION REQUIRED	MAINT./OVERHAUL INST. NO.	PAGE NO.
CHLORINATOR	CHECK VALVES	M	NO	3.20-A-11	14
CONTROL ROTOMETER	CHECK BUBBLE LINE	M	NO	3.31-D	17
DEHUMIDIFIERS (2)	INSPECT LUBE UNIT	A	YES	3.50-B	20
DEHUMIDIFIERS (2)	CHECK OPERATION	M	NO	3.50-A	20
PIT WET	CLEAN PIT	A	NO	7.10-A-1	25
WASTEWATER NO 1 PUMP	LUBEFLUSH MOTOR	A	YES	6.01-C	23
WASTEWATER NO 1 PUMP	SCOPE MOTOR BEARINGS	A	YES	6.01-F	23
WASTEWATER NO 1 PUMP	SCOPE PUMP BEARINGS	A	NO	6.01-F	23
WASTEWATER NO 1 PUMP	LUBE PUMP BEARINGS	S/A	NO	7.20-H	29
WASTEWATER NO 1 PUMP	CHECK WATER LUBE LINE	S/A	NO	7.20-N-2	30
WASTEWATER NO 1 PUMP	CHECK COUPLING	S/A	YES	3.40-B	18
WASTEWATER NO 1 PUMP	CHECK BALL VALVE	S/A	YES	8.30-D	36
WASTEWATER NO 1 PUMP	CHECK STRAINER SCREEN	S/A	YES	7.94-A	33
WASTEWATER NO 1 PUMP	CHECK MOTOR	M	NO	6.01-A-B	23
WASTEWATER NO 1 PUMP	CHECK PUMP	M	NO	7.20-E	29
WASTEWATER NO 1 PUMP	CHECK PACKING	M	NO	7.20-A	29
WASTEWATER NO 1 PUMP	CHECK DRAIN LINE	M	NO	7.20-E-1	29
WASTEWATER NO 2 PUMP	LUBEFLUSH MOTOR	A	YES	6.01-C	23
WASTEWATER NO 2 PUMP	SCOPE MOTOR BEARINGS	A	NO	6.01-F	23
WASTEWATER NO 2 PUMP	SCOPE PUMP BEARINGS	A	NO	6.01-F	23
WASTEWATER NO 2 PUMP	LUBE PUMP BEARINGS	S/A	NO	7.20-H	29
WASTEWATER NO 2 PUMP	CHECK WATER LUBE LINE	S/A	NO	7.20-N	30
WASTEWATER NO 2 PUMP	CHECK COUPLING	S/A	YES	3.40-B	18
WASTEWATER NO 2 PUMP	CHECK BALL VALVE	S/A	YES	8.30-D	36
WASTEWATER NO 2 PUMP	CHECK STRAINER SCREEN	S/A	YES	7.94-A	33
WASTEWATER NO 2 PUMP	CHECK MOTOR	M	NO	6.01-A-B	23

PREVENTIVE MAINTENANCE SCHEDULE - S-14

EQUIPMENT	TASK DESCRIPTION	FREQUENCY	ISOLATION REQUIRED	MAINT./OVERHAUL INST. NO.	PAGE NO.
WASTEWATER NO 2 PUMP	CHECK PUMP	M	NO	7.20-E	29
WASTEWATER NO 2 PUMP	CHECK PACKING	M	NO	7.20-A	29
WASTEWATER NO 2 PUMP	CHECK DRAIN LINE	M	NO	7.20-E-1	29
SUMP PUMP	INSPECT SUMP PUMP	S/A	YES	7.20-L-2	32
SUMP PUMP	CHECK OPERATION	M	NO	7.20-L-1	32
MAIN WATER STRAINER	CLEAN STRAINER	A	YES	7.94-A	33
GATE VALVES (2)	REPAIR GATE VALVES (2)	A	YES	8.30-A	35
FORCE MAIN BURIED VALVES (2)	OPERATE LUBE-VALVES	A	NO	8.30-F	36
SLIDE GATE	EXERCISE SLIDE GATE	A	NO	8.40-C	37
WATER WELL	CHECK TANK	S/A	YES	9.01-B	38
WATER WELL	CHECK AIR RELIEF VALVES	S/A	NO	8.10-C-4	34
WATER WELL	CHECK TANK	M	NO	9.01-B	38
WATER WELL	CHECK PUMPING RANGE	M	NO	7.20-P	30
WATER WELL	SOUND WELL	M	YES	9.01-C-1-2	39
REGULATOR FILTERS (2)	CLEAN FILTERS	S/A	YES	1.10-H	10
REGULATOR FILTERS (2)	CLEAN FILTERS	M	YES	1.10-H-3	10
STA-DRY FILTERS (2)	BLEED FILTERS	S/A	YES	1.10-H-4	10
STA-DRY FILTERS	BLEED FILTERS	M	NO	1.10-H-4	10
WASTEWATER PUMP CONTROLS	ALTERNATE PUMPS	M	NO	7.20-G-1	29
WASTEWATER PUMPS	CHECK PUMPING RANGE	M	NO	7.20-P	30
WASTEWATER PUMPS	RECORD HOURS-GALLONS	M	NO	6.10-J	24
STATION POWER SUPPLY	RECORD SMUD METER	M	NO	6.10-K	24
HOUSEKEEPING	CLEAN MOTORS	M	NO	2.40	13
HOUSEKEEPING	CLEAN PUMP UNITS	M	NO	2.40	13
HOUSEKEEPING	CLEAN STA. INTERIOR	M	NO	2.40	13
HOUSEKEEPING	CLEAN YARD-DRIVEWAY	M	NO	2.40	13


PRESSURE GAUGE & PRESSURE SWITCH
CONTROLS AS SPECIFIED
NOTE: WITHOUT AFTERCOOLER TANK DISCHARGE WILL BE ON THIS END OF RECEIVER
RELIEF VALVE
SHUT OFF VALVE
SUPPLY LINE
WATER INLET
AFTERCOOLER
WATER OUTLET
SIPHON DRAIN
STURDY FOUNDATION (CONCRETE SLAB OR TIMBER BOLTED TO FLOOR)

Pressure Tank Compressor
Drawing No. 1.10-G

PREVENTIVE MAINTENANCE ON AIR COMPRESSOR

INCLUDES THE FOLLOWING:

A. Keep unit clean

B. Check oil level in crankcase, add if needed

C. Drain condensate from receiver

D. Test safety valves

E. Clean suction air filter

F. Scheduled crankcase oil change

G. Check condition and tension of belts

H. Check all screws and nuts for tightness

AIR COMPRESSOR - 1.10
ISOLATION INSTRUCTION

A. PREREQUISITES:

Prior to the electrical isolation of an air compressor, ensure that the air compressor is operating normally.

B. ELECTRICAL ISOLATION:

Place the compressor motor power supply switch in the off position, lock in off position, and tag with a "Do Not Turn On" card to prevent unit operation.

C. MECHANICAL ISOLATION:

Close the air compressor discharge valve.

D. RESTORATION:

Mechanical Restoration: Open the air compressor discharge valve.

E. ELECTRICAL RESTORATION:

Unlock or untag the power switch and place in the on position.

F. OPERABILITY DEMONSTRATION:

Demonstrate the air compressor is operable by starting the air compressor and observing its operation through one complete cycle. If any portion of this system was opened, inspect that portion for leakage, i.e., oil, air, or water.

AIR COMPRESSOR - 1.10
MAINTENANCE INSTRUCTIONS

1.10A CONDITION CHECK

If compressor shows evidence of overheating or excessive noise, stop immediately until repairs are made. A compressor will run hot if running continuously. Check for vibrations. Keep compressor free from dirt and dust. Check for leaks of oil or grease.

1.10B 2 OIL CHANGE

1. Check crank case oil by turning compressor motor switch to off position and locking out if possible. Remove filler plug, oil should be at the lever of the filler opening or never below the low mark on the dip stick if so equipped.
2. To change crank case oil in a compressor, turn motor switch to off position, lock out if possible. Remove both drain and filler plugs. Drain out old oil thoroughly, replace drain plug and fill crank case with new oil to the proper line. See paragraph B-1. Replace fill plug. Run the compressor 3 or 4 minutes. Shut it off and allow the oil to settle. Recheck, adding more oil if necessary.

1.10F 1 SMALL COMPRESSOR LUBRICATION

Small compressor bearing lube can be either oil cups or grease fittings. If equipped with oil cups, five or six drops of oil are enough. If equipped with grease fittings, lube very sparingly.

1.10F 3 DRAIN CONDENSATION

Drain condensation from the tank through the drain valve at the bottom.

1.10H 2 AIR FILTER

Air cleaners with felt pads and screens-remove cover, wipe out interior, wipe the oil impregnated pad with a solvent dampened rag. Add three or four drops of oil to the felt. Clean the wire screen with solvent and dry thoroughly.

1.10H 4 STA-DRY FILTERS

Bleed sta-dry filters periodically by slowly opening, in turn, all drain cocks on filters or the air line.

1.10I SAFETY VALVE

When a compressor is controlled by a pressure switch for a high and low limit, a safety valve is installed. To test the safety valve, lift the lever allowing air to escape; this will insure the valve is operating.

1.10J GAUGE CHECK

Check pressure gauge for correct pressure of this particular line or unit. If you have reason to believe the pressure gauge is not accurate or the demand of the pressure switch does not coincide with pressure gauge and you want to check which is at fault, replace with a pressure gauge known to be accurate. If the pressure gauge is combined with a dampener, remove, disassemble and clean. On the pulsation type dampener for air, set the pin in hole 5.

2.02B BELT CHECK

1. Check tension and wear. Rubber wearings near the drive are signs of improper tension, incorrect alignment or damaged sheaves. If tightening a belt does not correct slipping, check for overload, oil on the belt or other possible causes. Never use belt dressing to stop a V-belt slipping.

2. When belts need replacing, never replace one V-belt on a multiple belt drive. Replace the complete set with a set of matching belts.

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VENTILATION BLOWER - 2.20
MAINTENANCE INSTRUCTIONS

PREREQUISITE

Removal of the ventilation blower from service requires the substitution of an equivalent ventilation blower to maintain adequate ventilation inside Station S-14 while the main blower is out of service. Observe all pertinent safety practices when performing maintenance under this condition.

2.20A INSPECTION

1. Open the ventilation blower circuit at the wall panel.
2. Disassemble the unit and check the frame, cover, and damper for rust or corrosion. Clean with solvent. Paint if needed.
3. Check that the vibration damper and springs are operating freely.
4. If the motor is equipped with sealed bearings, no lubrication is required.
5. If the motor bearing housing is equipped with plugs, remove and check if lubricant is grease or oil. Lubricate accordingly. (If grease refer to Par. 6.01C 2-7).
6. Check for worn or frayed electrical wires. When reassembled, close the blower circuit at the wall panel and test for operation and vibration.

ISOLATION

Turn the ventilation blower power switch in control panel to the off position. If possible, lock in the off position to prevent accidental power supply to unit.

BUILDING MAINTENANCE AND INSPECTION - 2.40

A. LOCKS

Oil locks with a light oil, preferably a spray oil. Make sure all electrical panel locks, padlocks, and door locks work freely. Replace all defective locks.

B. LIGHTS

Check for broken or burned out light fixtures. Replace burned out or broken bulbs. Report broken or damaged switches.

C. DOORS

Check hinges, catches, and seals on all doors. Check that they swing freely and close tightly.

HOUSEKEEPING

A. Equipment and wall surface cleaning can best be done with a rag moistened with a cleaning solution. Avoid contact with electric terminals. If this is not possible, isolate the system according to the applicable isolation instructions before cleaning. Floors must be mopped with a cleaning solution.

B. Gather the accumulated debris from the exterior yard area and place it in a waste container carried in the service vehicle.

ELECTRICAL PREVENTIVE MAINTENANCE

Isolate all circuits prior to performing maintenance according to the applicable isolation instruction. Inspect electric connectors for looseness and insulation cracking. Tighten and repair when necessary. Do not attempt to maintain or work on live circuits.

CHLORINATOR - 3.20-A
MAINTENANCE INSTRUCTIONS

3.20A 1 ISOLATION

Turn off chlorine supply; close tank valve, close containment valve. Turn off injector water supply. (Be sure all chlorine is exhausted from unit before turning off water.)

3.20A 7 PRESSURE REDUCING VALVE

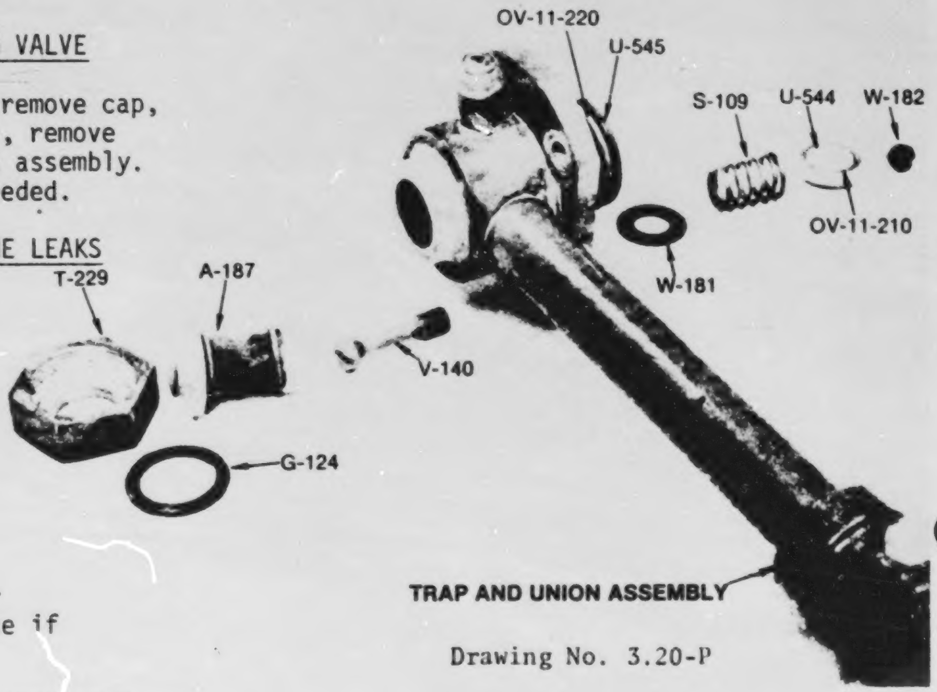
Remove protecting cap nut, remove cap, remove silver lock nuts (2), remove needle assembly, clean seat assembly. Reassemble new gasket as needed.

3.20A 9 CHECK FOR CHLORINE LEAKS

Use ammonia and check all chlorine connections for leaks. (If white smoke appears, leak present.)

3.20A 11 CHECK VALVES

Check valves for leaks around stems and for damaged threads. Check flex lines for kinks and/or signs of corrosion. Replace if needed.



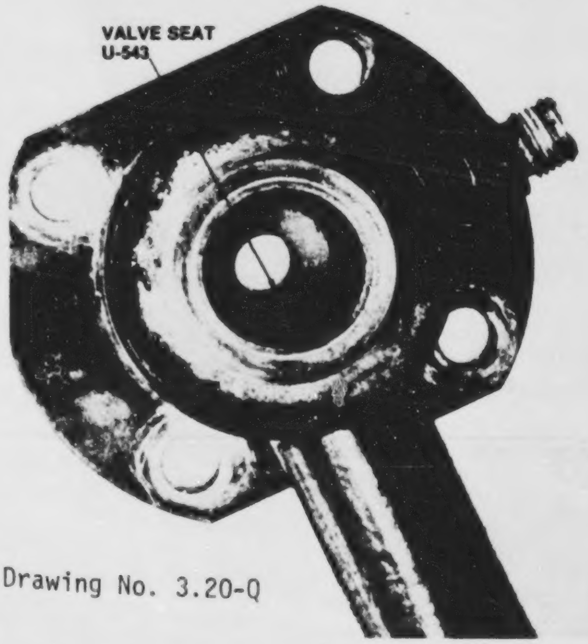
Drawing No. 3.20-P

3.20A 15 CLEANING CHLORINATOR BODY

Use a damp cloth, then wipe dry. Apply a small amount of polishing wax and wipe with dry cloth.

3.20A 16 CLEANING VALVE SEAT AND VALVE PLUG

To disassemble capsule, remove large hexagonal nut (T-229) on back of capsule and remove the secondary inlet filter assembly (A-187). Insert small screw driver into the inlet to hold the inlet valve plug (V-140) against valve seat, unscrew the vent screw (W-182), the valve plug, spring retainer, spring and vent plug may now be removed. Unscrew the adaptor seal plug (U-545) and remove the valve seat (U-543).

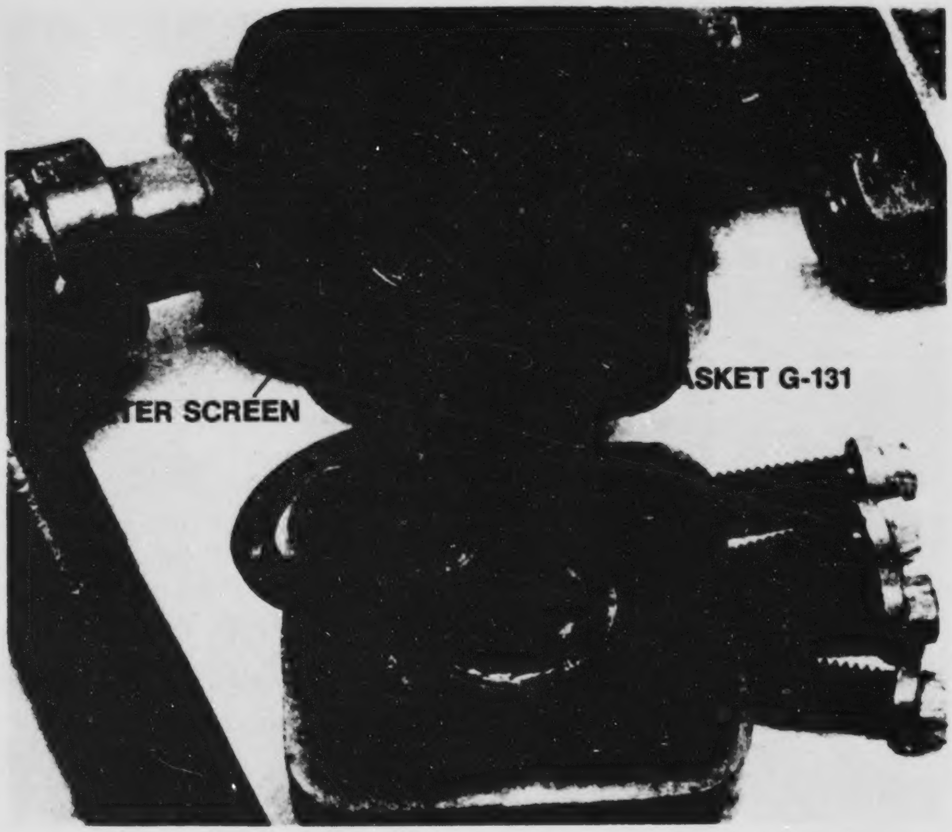


Drawing No. 3.20-Q

3.20A 17 CLEANING PRIMARY FILTER

Remove the four (4) bolts holding the filter cover on and remove the cover and screen from body. Clean the screen by submerging in hot water with a detergent and remove dirt with a coarse bristle brush. Dry thoroughly.

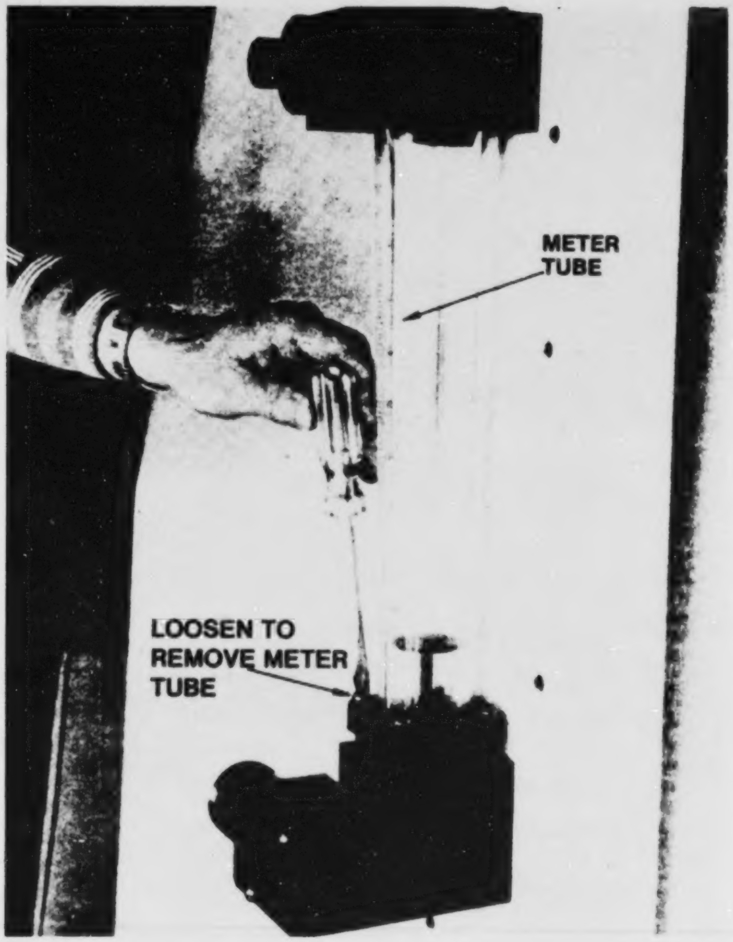
Secondary filter (A-187).
Clean in the same manner.



Drawing No. 3.20-B

3.20A 18 METER TUBE CLEANING

To remove metering tube loosen the 4 screws at the bottom meter fitting. Press downward on the tube and tilt out at the top until tube is clear of top meter fitting. Remove float carefully and clean tube by pushing through a clean lint free swab dampened with a cleanser. Use clean dry swab to dry tube.



Drawing No. 3.20-S

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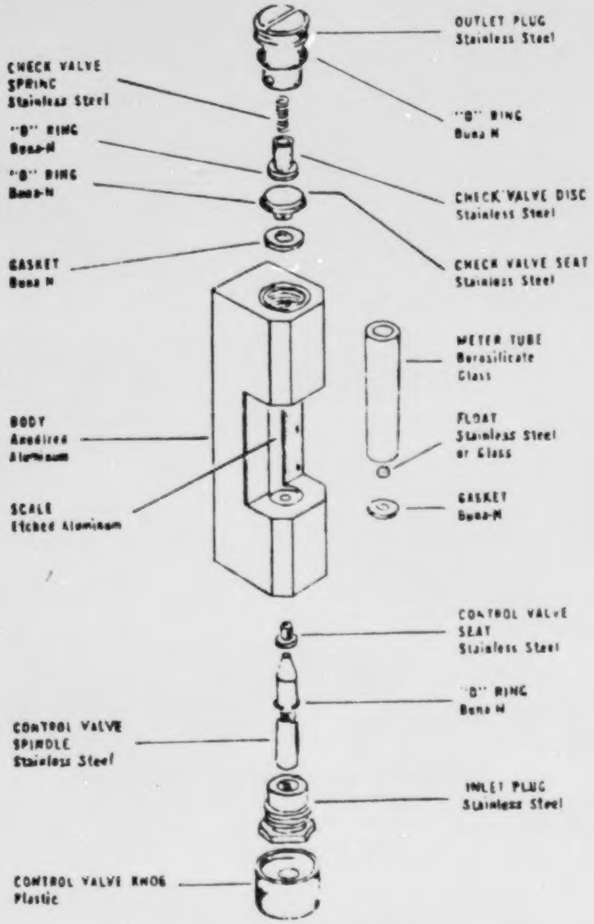
3.31D ROTOMETER

Check bubble line. If rotometer has a marking on the panel, check that the setting corresponds to the mark.

MANUAL PURGE

1. Depressing a button or moving a switch or valve on or in the panel marked "purge" will automatically shut off the air to the pressure mechanism and provide a direct flow of air to the compression bell, thereby purging the line. When released or switch thrown back to operate, controls go back to normal operation.


OUTLET PLUG
Stainless Steel
CHECK VALVE SPRING
Stainless Steel
"O" RING
Buna N
"O" RING
Buna-N
"O" RING
Buna-N
CHECK VALVE DISC
Stainless Steel
GASKET
Buna N
CHECK VALVE SEAT
Stainless Steel
METER TUBE
Borosilicate Glass
BODY
Anodized Aluminum
FLOAT
Stainless Steel or Glass
SCALE
Etched Aluminum
GASKET
Buna-N
CONTROL VALVE SEAT
Stainless Steel
"O" RING
Buna N
CONTROL VALVE SPINDLE
Stainless Steel
INLET PLUG
Stainless Steel
CONTROL VALVE KNOB
Plastic

Rotometer
Drawing No. 3.31A

COUPLING - 3.40
MAINTENANCE INSTRUCTIONS

3.40A GENERAL

Unless couplings between the ends of the driving shaft and driven shaft of a pump or any other piece of equipment are kept in proper alignment, breaking or excessive wear result in either or both the driven machinery and the driver. Burned out bearings and sprung or broken shaft are some of the damages caused by misalignment. To prevent these damages, periodic checking and maintenance must be performed. Any maintenance performed on couplings, either checking or re-alignment, must be done with the motor switch in "off" position and special lock on the panel switch.

1. Flexible couplings permit easy assemble of equipment, but must be checked for both horizontal and vertical alignment. Distance between coupling halves must be exactly the same at all points. A straight edge must have continuous contact when laid across both couplings. Set screws must be tight and if found continually loose must be replaced. Realign when necessary.

2. If there is a shield or guard over the coupling, check that bolts are tight and guard will not in any way touch the coupling or shaft.

3.40B CHECK FLEXIBLE COUPLING

Realign when necessary, using a straight edge and thickness gauge or a Dial Indicator.

1. Remove coupling pins, rigidly tighten driven equipment, slightly tighten bolts holding the drive. To correct horizontal and vertical alignment, shift or shim drive to bring coupling halves into position so no light can be seen under a straight edge laid across them. Place straight edge in four positions. Hold a light back of the straight edge to help insure accuracy. Check angular misalignment with a thickness or feeler gauge inserted at four places to make certain space between the coupling halves is exactly the same at all points. When proper alignment has been secured, coupling pins can be put in place easily using only finger pressure. Never hammer pins into place.

2. In couplings where pins are solid on the coupling halves and fit into rubber eyelets, or couplings which mesh together with rubber or nylon inserts, if properly aligned and loose on the shafts, coupling halves should slide together with finger pressure.

3. To check coupling alignment with a dial indicator, disconnect the coupling halves. Fix a dial indicator to one of the shafts or coupling hubs. Span the indicator arm across the mating shaft or coupling hub. Scribe index lines on the coupling halves or mark where the indicator point rests. Set indicator dial to zero. Slowly turn both coupling halves so that the index lines match, or indicator point is always on the mark. Observe dial reading to determine whether driven or driver needs adjustment. Acceptable parallel alignment and acceptable angular alignment occurs when one half of the total indicator reading (complete turn), does not exceed manufacturer's limits.

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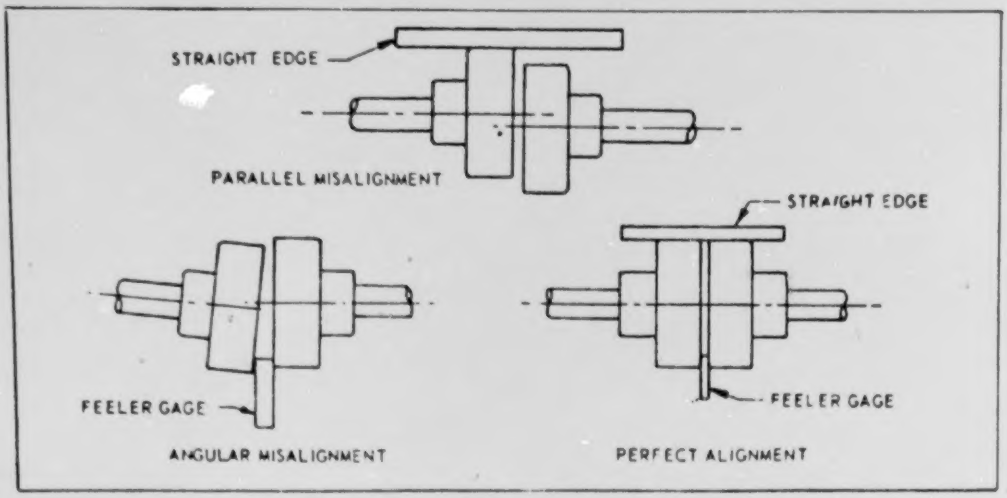
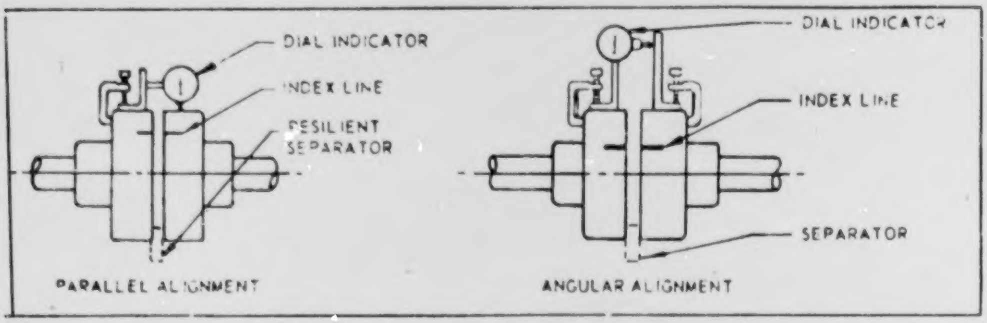
3.40B 3 (continued)

These limits depend upon size and speed of the coupling. Refer to manufacturers specification limits. Correct parallel and angular misalignment by slightly shifting the leveling shims under the base plate of the driver. Retest after each shifting of shims.

COUPLING ALIGNMENT


STRAIGHT EDGE
PARALLEL MISALIGNMENT
STRAIGHT EDGE
FEELER GAGE
ANGULAR MISALIGNMENT
FEELER GAGE
PERFECT ALIGNMENT

Testing alignment, feeler gage and straight edge


DIAL INDICATOR
INDEX LINE
RESILIENT SEPARATOR
PARALLEL ALIGNMENT
DIAL INDICATOR
INDEX LINE
SEPARATOR
ANGULAR ALIGNMENT

Testing alignment, dial indicator

Drawing No. 3.40C

3.50A OPERATIONAL CHECK

Set dehumidifier dial on dry for normal operation. Check for condensation on the walls of the station. If condensation is noted, reset dehumidifier to very dry until moisture is cleared up. If the coils of the dehumidifier are frozen or frosted, turn the unit off until they defrost.

3.50B LUBE AND INSPECT UNIT

Disconnect the cord from the wall outlet. Disassemble the dehumidifier. Clean throughout, including drip pan and drain hose. Lube fan motor with about three drops of light oil. Reassemble. Replace the cord plug in the wall outlet and test.

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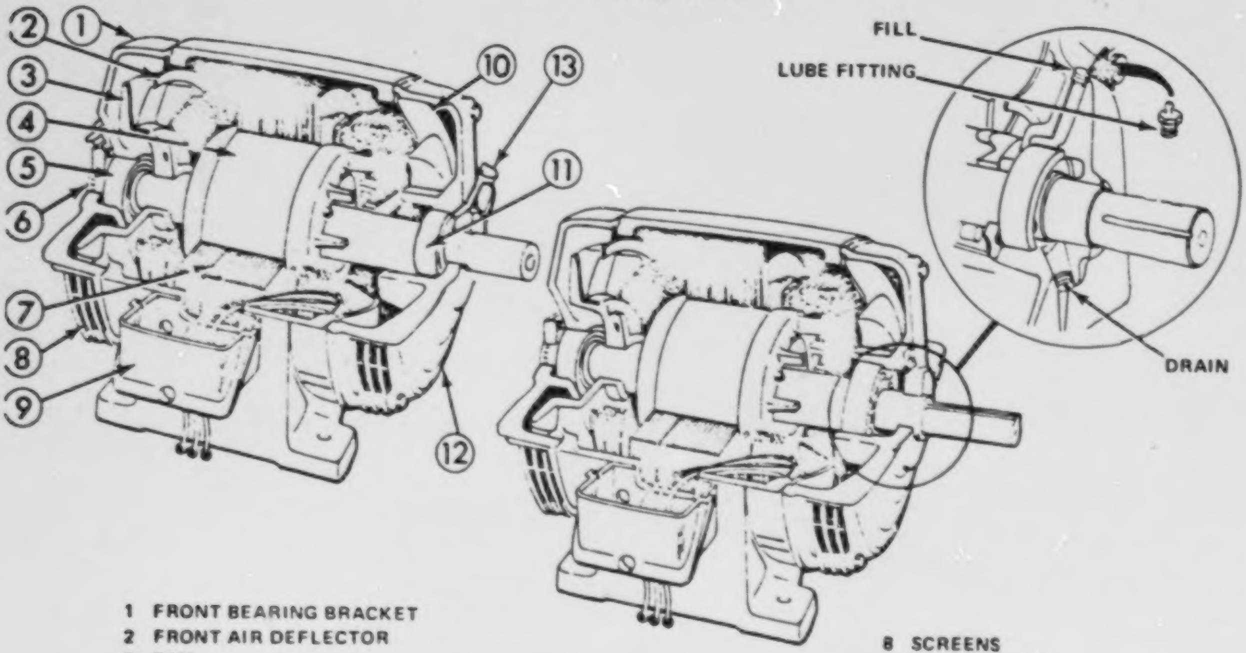
MOTOR LUBRICATION

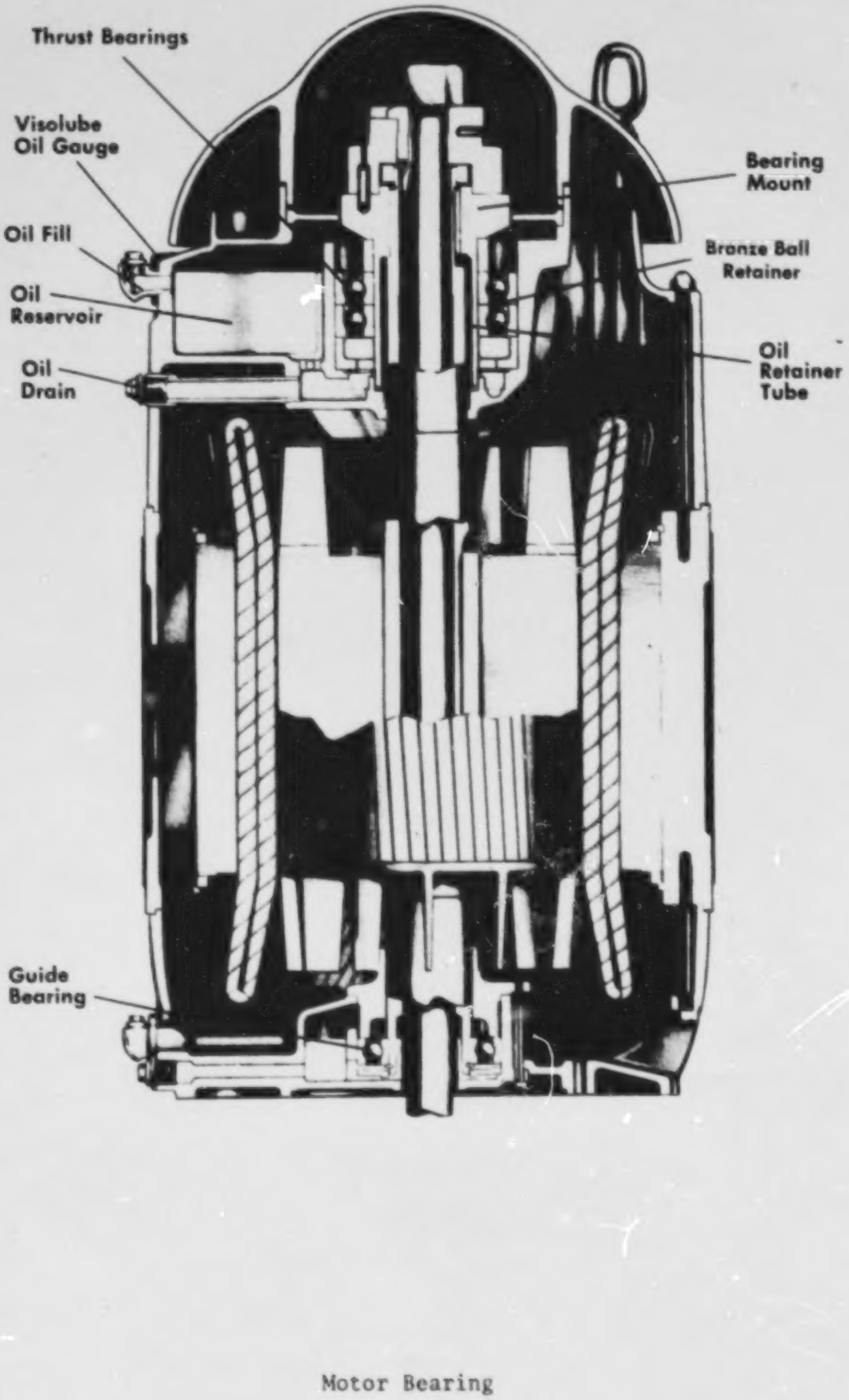

2
1
3
4
5
6
7
8
9
10
13
11
12
FILL
LUBE FITTING
DRAIN

1 FRONT BEARING BRACKET
2 FRONT AIR DEFLECTOR
3 FAN
4 ROTOR
5 FRONT BEARING
6 END COVER
7 STATOR

8 SCREENS
9 CONDUIT BOX
10 BACK AIR DEFLECTOR
11 BACK BEARING
12 BACK BEARING BRACKET
13 OIL LUBRICATION CAP

Electric Motor
Lubrication

Drawing No. 6.01 B


Thrust Bearings
Visolube Oil Gauge
Oil Fill
Oil Reservoir
Oil Drain
Bearing Mount
Bronze Ball Retainer
Oil Retainer Tube
Guide Bearing

Motor Bearing

Lubrication

Drawing No. 6.01 C

ELECTRIC MOTORS - 6.01
MAINTENANCE INSTRUCTIONS

6.01A CONDITION CHECK

1. Keep motors free from dirt and dust.
2. Keep operating space free from articles which may obstruct air circulation.
3. Check for excessive grease or oil leakage from bearing fill lines and drain lines.

6.01B UNUSUAL CONDITION CHECK

Note and record in the station log, any of the following conditions:

1. Unusual operating noises.
2. Motor failing to start or come to speed normally.
3. Motor or bearings which feel or smell hot.
4. Continuous or excessive sparking of the communtator or brushes.
5. Intermittent sparking at brushes.
6. Hot or blackened communtator.
7. Brush chatter.
8. Smoke, charred insulation, or solder whiskers, extending from the armature.
9. Excessive humming.
10. Regular clicking.
11. Rapid knocking.
12. Vibration.
13. Fine dust under couplings having rubber buffers or pins.

6.01C LUBE FLUSH

1. Turn motor to "off" position. If there is a lock out switch, lock on panel switch of the motor you are preparing for lubrication.
2. Wipe pressure gun fitting, bearing housing and relief plug with a clean plug.
3. Before using grease gun always remove relief plug, opposite side of bearing from grease fitting. This will prevent excessive pressure in housing which might rupture bearing seals.
4. Use clean screw driver or similar tool to remove hardened grease from relief hole and permit excess grease to run freely from bearing.
5. Remove all fittings, tools, rags, etc. from off the motor.
6. Place the unit back in service. Start the motor. While motor is running, add grease with hand operated pressure gun unit until it flows from relief hole.

6.01F SCOPE BEARINGS

Check all bearings using a stethoscope. Listen while the motor is being started and shut off. Listen also during motor operation for whines, gratings or uneven noises in several locations around the bearing housing as close as possible to the bearing. If the unusual noises are heard, pinpoint the location, record it in the station log, and report the condition to the responsible Maintenance Foreman.

ELECTRICAL MOTOR ISOLATION

Place the electrical control switch which is in the control panel in the off position and lock in the off position with the special lock. If there is a secondary switch at the motor, lock this in the off position also. Both switches on off position will insure against accidental power supply.

6.10J COUNTER-GALLONS-HOUR-ETC.

1. Where a unit is equipped with a counter or a register to record gallons pumped or a register to record hours the unit has run, take the reading from the counter or register and record it on a special log sheet provided for that purpose by following directions on the sheet. When reading meters with a revolving register, note if there are zeros (00) printed on face of the meter at the right of the revolving figures. If there are zeros, add them to the register number. Also check to see what the meter reading measure is such as cu. ft. or gallons. Log the units of measurement. For example, if the meter reading is in gallons and there are two zeros, a register number of 7439 would be logged on the form as 743900 gals. Also any meters or gauges registering amps, volts, air, etc., take the reading from the panel gauge or meter if so requested.

FLOW RECORDER

2. The flow recorder is regulated by a magnetic flow meter on discharge line. A fold chart receives the resultant signal and is recorded by pin and ink system. There is a recording of P.S.I. on the same fold chart.

6.10K ELECTRIC POWER METERS

1. There are various types of electric meters. The most common and more frequently used meter has four or five registers or dials with pointers. Two of the pointers move in one direction, the others in the opposite direction. To read and log a meter of this type, write down from left to right the numbers the pointers have passed. Before writing down any number the pointer has passed, always check the direction of the pointer to get the correct number. Suppose one of the pointers points directly to the "4". Before writing down 4, look at the pointer on the dial to the right, if it has not quite reached the "0" then the pointer which seemed to point directly to 4 has not actually reached the 4, so write down 3 instead. If the pointer to the right has passed the "0" then the correct number would be 4.

2. A special log sheet can be provided to log the meter reading. On some meters there may be a notation to multiply the reading by 40 or 1600 or some other figure. Put this multiplication factor in the space provided. If previous and present readings are required, use direct meter readings and subtract before multiplying by the multiplication factor.

WET PITS - 7.10
MAINTENANCE INSTRUCTION

7.10A INSPECTION AND CLEANING

1. When cleaning a wet pit, manhole or sump (where water pressure is available either at the station or portable water tank with pressure), check the pit for any floating debris which might plug or damage a pump.

   If there is debris, remove it.

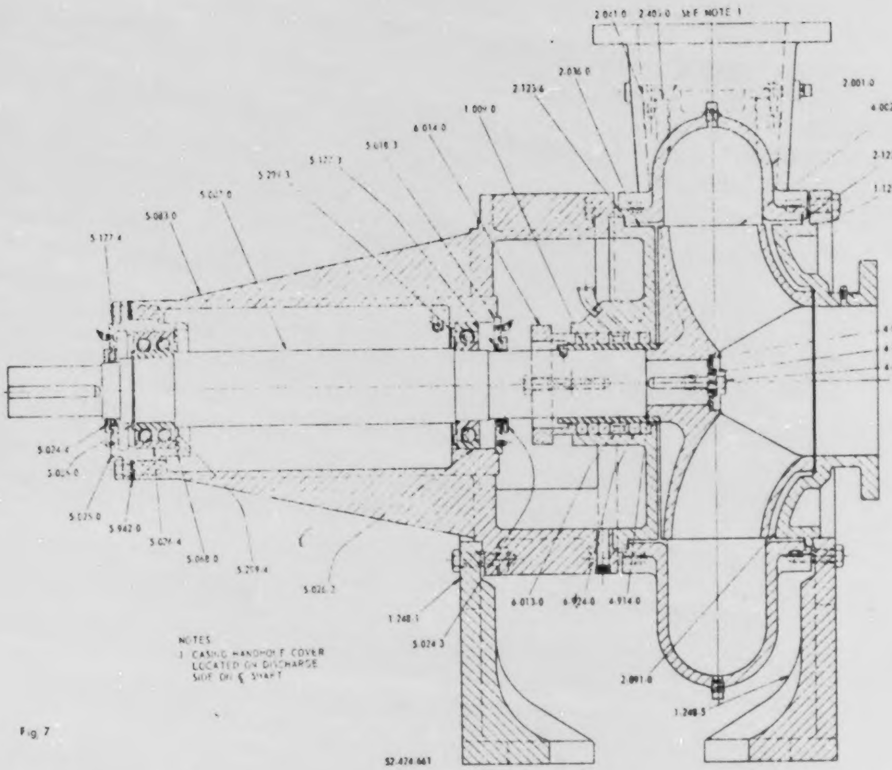
   Use a hose and nozzle to wash the solids off the pit walls while the pit is being pumped down.

   If solids are heavier than normal, pump out by stages.

   If water pressure does not remove the solids from the walls, the pit walls must be scraped.

DEFINITION OF WET PIT OR ENCLOSED AREA: is defined by the State of California, Division of Industrial Safety as: The interior of storm drains, sewers, vaults, utility pipe lines, manholes, and any other structure which is similarly surrounded by confining surfaces so as to permit the accumulation of dangerous gases or vapors.

PUMP CENTRIFUGAL - 7.20


2-041-0 2-405-0 SEE NOTE 1
2-036-0
2-123-6
1-009-0
6-014-0
5-018-3
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5-299-3
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4-002-0
2-123-5
1-127-0
4-074-0
4-917-0
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5-026-3
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5-024-3
6-013-0
6-924-0
4-914-0
2-091-0
1-248-5
52-474-661

NOTES
1 CASING HANDHOLE COVER LOCATED ON DISCHARGE SIDE OF ℄ SHAFT

Fig. 7

Cat. No.	Name	Cat. No.	Name
1-009-0	Shaft Sleeve	5-018-3	Bearing Cover
1-127-0	Cover Clamping Ring	5-024-3	Deflector (Inboard)
1-248-1	Foot Support (outboard)	5-024-4	Deflector (Outboard)
1-248-5	Foot Support (inboard)	5-025-0	Bearing Cartridge
2-001-0	Casing	5-026-3	Ball Bearing (Inboard)
2-036-0	Stuffing Box Cover	5-026-4	Ball Bearing (Outboard)
2-041-0	Handhole Cover (Casing)	5-068-0	Snap Ring (Bearing Cartridge)
2-091-0	Suction Cover	5-083-0	Frame
2-123-5	Gasket (Suction Cover)	5-086-0	Snap Ring (Shaft)
2-123-6	Gasket (Stuffing Box Cover)	5-177-3	Grease Seal (Inboard)
2-405-0	Handhole Cover Gasket (Casing)	5-177-4	Grease Seal (Outboard)
4-002-0	Enclosed Impeller	5-299-3	Grease Retainer (Inboard)
4-037-0	Impeller Screw	5-299-4	Grease Retainer (Outboard)
4-074-0	Impeller Washer	5-942-0	Adjusting Shims
4-914-0	"O" Ring (Impeller)	6-013-0	Seal Cage
4-917-0	Retaining Washer	6-014-0	Gland (Split)
5-007-0	Shaft	6-924-0	Packing (Set)

Drawing No. 7.20-A

WASTEWATER PUMPS - 7.20
ISOLATION INSTRUCTIONS

PREREQUISITES:

Prior to the electrical isolation of a wastewater pump, ensure that the motor and pump are operating.

ELECTRICAL ISOLATION:

Place the electrical control switch in the off position and lock in the off position with the special lock. There is a secondary lock out switch at the motor for the purpose of eliminating power to unit without using the switch panel. Both switches in off position will insure against accidental power supply.

CLOSE ALL VALVES.

RESTORATION:

Open all valves.

ELECTRICAL:

Unlock power supply switches and place in the on position.

OPERABILITY DEMONSTRATION:

Demonstrate the wastewater pump is operable by starting the pump and observing if it is operating normally.

After the unit has run for a short period under normal operating conditions, it should be shut down and checked for alignment. All alignment checks must be made with the coupling halves disconnected and again after they are connected. Remember that the correction of alignment in one direction may alter the alignment in the other direction; therefore, it is necessary to recheck in all directions after making any adjustment. As in any piece of precision machinery, it is economical to keep your pumping unit in the best operating condition by checking the alignment periodically.

The stuffing box packing is subject to wear and should be given regular attention. If normal inspection indicates that the stuffing box is operating satisfactorily with no excessive heat or leakage of the sealing liquid, it should not be tampered with. However, if leakage of the sealing liquid has increased and cannot be reduced by a slight tightening of the glands, it is time to shut down the unit and repack the box or check the sleeve surface for roughness.

When the pump starts to show normal wear, it is advisable to order replacement parts, thus avoiding excessive lost time which may occur if repairs are not ordered until the pump breaks down. Scoping bearings will determine pending bearing failure.

7.20A WATER SEAL PACK GLANDS

1. See that the packing box is protected with a clear water supply at all times. Make sure that pressure at water seal valve entrance is not less than pump shut off head. Check water line pressure gauge. Check packing gland for leakage. The packing is subject to wear and should be given regular attention. If normal inspection indicates that the packing is operating satisfactory with no excessive heat or leakage of the sealing liquid, it should not be tampered with. However, if excessive leakage is found, tighten gland nuts evenly just enough to stop excessive leakage. After adjusting gland, be sure shaft turns freely by hand. A strap wrench may be needed on large pumps. If serious leakage continues, renew packing.

7.20B GREASE SEAL PACK GLANDS

1. When grease is used as a packing seal, maintain constant pressure on the packing during operation. When a grease cup is used, keep it loaded with proper lubricant. Turn the cap down two or three turns until resistance is felt. If this uses part of the grease in the cup, remove and refill. When greasing a fitting, two or three strokes of the gun is enough.

7.20E CONDITION CHECK

1. Keep exterior of pump clean. Keep drains open. Run pump manually. Check if pumping at full capacity. This can be done numerous ways, depending on the design of the station. Check the discharge if convenient. Watch the check valve. Watch the lowering of the pit. Check for excessive grease or oil leakage from the bearings. Look for black powdery substance near bearings or shaft. Note if pump feels or smells hot. Note any unusual noises or vibrations. Check guards and shields.

7.20G OPERATE PUMPS ALTERNATELY

1. If alternator is not installed and two or more pumps of the same size are installed, alternate their use to equalize their wear.

2. Switches are marked either alternator or selector. In some electrical installations a pump will not run on manual unless the selector switch is turned to that particular pump. Thus, if you wish to run #1 pump on manual, turn the selector switch to #1.

7.20H LUBRICATION

1. The importance of proper lubrication cannot be over emphasized. It is difficult to say how often a bearing should be greased since that depends on the conditions of operation. One ounce of grease should be added at regular intervals, but it is of equal importance to avoid adding too much grease. Excess grease is the most common cause of overheating. If possible remove the bearing cover and visually inspect the grease in the housing. If unable to remove the cover, remove the relief plug and add grease cautiously (five or six strokes of the gun are enough).

7.20N WATER LUBE LINE CHECK

1. Close the gate valve or shut off cock in the water supply line to the pump packing box. Disconnect the water lube line at the union and remove the section of the line from the union to the packing box. In case of a flexible hose, remove at the packing box inlet. Check the inlet to the lantern ring for grease or particles of packing. Start the pump, slowly open the supply line valve. The solenoid valve in the lube line should now be open and water flowing through the line. Shut off the pump; this should stop the flow of water as the solenoid valve should automatically close. Reinstall the lube line. If it consists of pipe, use suitable thread compound. Make sure the gate valve or shut off cock is fully open. Put the unit back in service. Run the pump. Check the packing leakage; adjust if necessary.

7.20P PUMPING RANGE (On and Off levels)

1. Wastewater lift, storm drain and other types of pumps may have an automatic set pumping range. The control for the range can be a bubble line, float, electrode or in case of a water well pump, a pressure switch. The test is to check the on and off levels which are set for all pumps unless manually operated. There are several ways of checking pumping levels. One way is with a moderate or good flow of water, allow the pit to fill until the lead pump comes on automatically. Check that the pump starts at the correct level. Shut this pump off and let the pit keep filling up until the second pump starts. Check the starting level of this pump and continue with the same procedure until all pumps have been tested for starting level. Next turn all pumps on automatic and check the stop level as each one stops. Variations of this procedure will have to be made due to installation of the controls in a particular station. For example one pump may be set not to run while two others are running, thus this pump would have to be checked independently. Make sure all pump switches are on automatic before leaving the station. With water well pumps and pressure switches, test the pressure on and off range. As there is a delay on water well pumps before starting, it would be more accurate to watch the mercoid switch to see that it trips at the correct pressure. Should it be necessary, the well can be isolated by closing the tank outlet valve. Then the water can be drained by opening the tank drain valve until the pressure is down and the pump comes on automatically. Close the drain valve. Check both on and off settings. After checking the range, open the outlet valve. At anytime any pumping levels do not correspond with the settings for the station pumps and the reason cannot be readily found and corrected, report it to your foreman.

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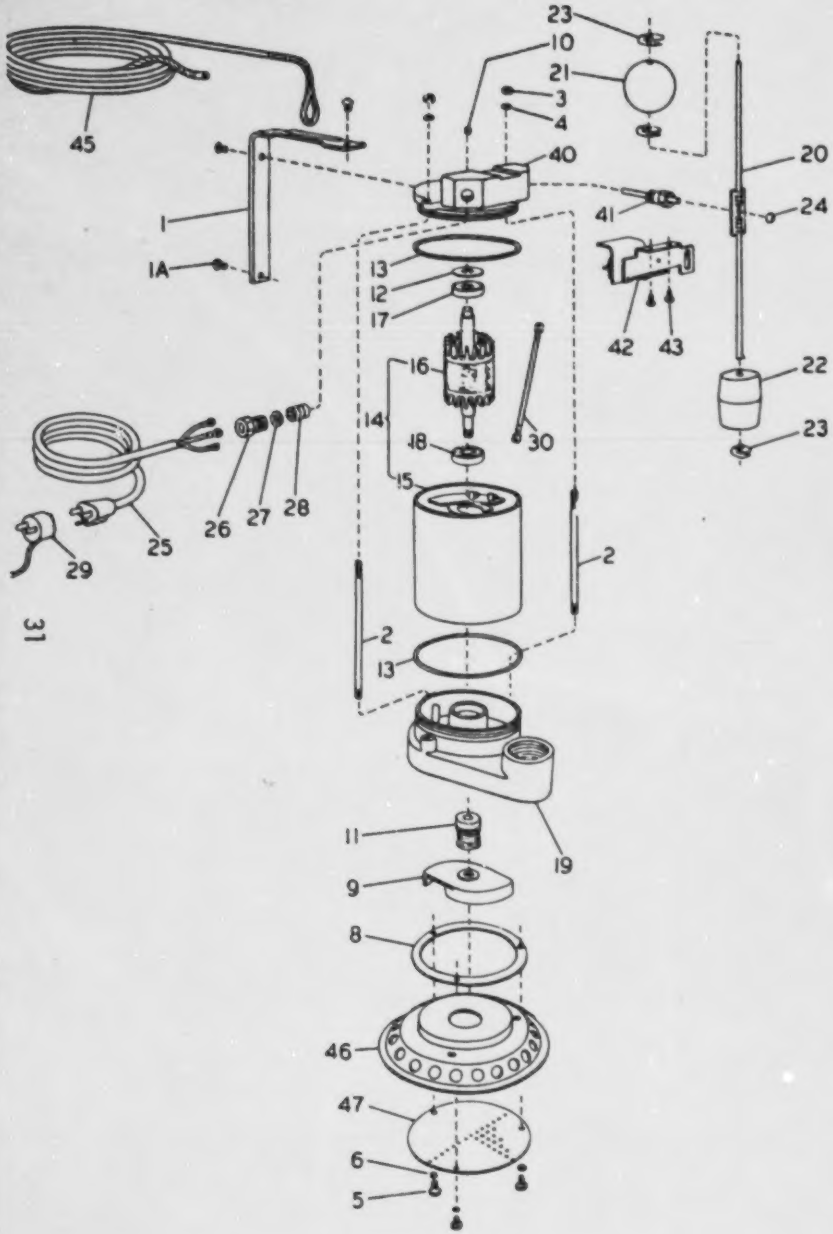

Drawing No. 7.20-C

Model PCD-6 **⅓ HP, 115V.**

REPAIR PARTS LIST

Key No.	Part Description	No. Used	Part Symbol
1	Handle	1	PS54-5
1A	Machine Screw #10-24 x 5/16" Lg. Truss Head	3	U30-583C
2	Stud — ¼-20 x 7⅜" Lg.	2	U30-619C
3	Nut — ¼-20 Hex	2	U36-36C
4	Lockwasher — ¼"	2	U43-10C
5	Capscrew — ¼-20 x ½" Lg. Hex Hd.	3	U30-50C
6	Washer — Plain — ¼"	3	U43-60C
8	Gasket (as Req'd.)	1	PS20-3
9	Impeller	1	PS5-2P1C
10	Pipe Plug — ¼" NPT Soc. Hd.	1	U78-95C
11	Shaft Seal — John Crane Type 6	1	U9-103
12	Bearing Loading Spring 202	1	PS18-7
13	"O" Ring 5⅛ x 5⅜ x ⅛	2	U9-114
14	Motor — ⅓ HP, 115 V	1	PS118-15
15	Stator	1	PS18-35
16	Rotor	1	PS18-34
17	Bearing — MRC #7109	1	U18-682
18	Bearing — MRC #203SFZ	1	U18-628
19	Volute	1	PS1-7BB
20	Float Rod Assembly	1	PS128-3
21	Float — 2½" Dia. x ⅛" Hole	1	PS28-7
22	Weight (Control #502)	1	PS28-6
23	Speed Clip #C26046SS-014-27	3	PS28-8
24	Float Rod Ring	1	PS28-3
25	Cord & Plug (25' Lg.)	1	U17-337
26	Packing Gland	1	PS16-1
27	Washer	1	PS43-1
28	Packing Ring	3	PS21-1
29	Adapter Plug	1	U17-99
30	Lead — Switch to Motor	1	PS18-30
40	Upper End Bell	1	PS3-8B
41	Lever Arm Assembly	1	PS178-2
42	Micro Switch Assembly	1	U117-310
43	Machine Screw #8-32 x 1/4'' Lg. Rd. Hd.	2	U30-111C
45	Plastic Rope (24' Lg.)	1	U97-21
46	Base	1	S4-7D
47	Strainer	1	S8-7

SUMP PUMPS - 7.20L
MAINTENANCE INSTRUCTIONS

7.20L 1 OPERATIONAL CHECK

Fill the sump basin and verify that the pump starts automatically and stops at the proper level.

7.20L 2 INSPECTION

A. Pump all the water possible out of the basin. Isolate the sump pump according to isolation instruction.

B. Disconnect the pump at the union and remove from the basin.

C. Remove the bottom cover or strainer and check the impeller. Clean the entire unit of rust, grease or corrosion.

D. Check the float for pin holes or wear spots. Replace if necessary.

E. Put a thin film of grease or oil on the float rod and rod guides.

F. Before returning the sump pump to the basin,test the check valve by slowly opening the discharge gate valve. If water flows from the line, the check valve is leaking. In this situation, close the gate valve and repair or replace the check valve.

G. Clean the basin thoroughly and reinstall the pump.

H. Restore the pump to service according to isolation instruction.

Fill the sump basin until the pump automatically starts. Verify that the pump operates smoothly and then stops at the proper level.

ISOLATION INSTRUCTION

A. PREREQUISITES

Prior to the isolation of the sump pump, pump the basin as dry as possible.

B. ELECTRICAL ISOLATION

Remove the sump pump fuse or remove the electrical plug from the wall outlet, whichever is applicable.

C. MECHANICAL ISOLATION

Close the discharge gate valve.

D. RESTORATION

1. Open the discharge gate valve.
2. Replace the sump pump fuse or reconnect the electrical plug to the wall outlet.

7.94A INSPECTION AND CLEANING

1. Single basket strainers are only used where flow can be interrupted as equipment must be shut off and valves closed to remove and clean the basket.

2. Twin strainers are cleaned without interrupting the flow. There are several types, one having a flow switch valve which will divert the flow from one basket to the other, thus permitting removal of the out of service basket for cleaning. The access covers of the chambers may have an air release cock. If so, open the pet cock before removing the cover. Another type of strainer has two gate type sliding valves. In this type both valves are always turned the same way, thus opening one passage through the strainer and closing the other.

3. If there is a valve at the base of the strainer or sand trap, open this valve and flush until water runs clear.

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8.10C 4 CHECK AIR RELIEF VALVE

To inspect and clean water tank air relief valves, close the gate valve in the air line and the gate valve in the water line to the air relief valve. Open the drain valve to relieve pressure. Remove the air valve from the line. Disassemble. Check float ball, spring, needle valve and orifice. Clean out all rust and corrosion. Reassemble. Check that the needle valve and orifice are aligned and that the spring is operating correctly. Flush the water line before replacing the air relief valve.

8.30 GATE VALVES

A. Operate inactive gate valves to prevent sticking.

B. Adjust the stem stuffing box packing tight enough that it will not leak, but not so tight that the stem turns with difficulty.

C. Lubricate the packing with a few drops of oil to eliminate excessive friction between the valve stem and the packing.

Modern gate valves can be repacked without removing them from service. Before repacking, verify the gate valve is in the fully opened position. This will prevent excessive leaking when the packing is removed.

REPACKING

REPACK GATE VALVE AS FOLLOWS:

A. Remove all packing from the stuffing box.

B. Clean the valve stem with fine emery cloth.

C. Insert new split ring packing in the stuffing box, staggering the joints and tamping down while inserting.

D. Place a few drops of oil on the stem and tighten down the packing just enough to keep it from leaking.

8.30D BALL VALVE (AUTO. STOP AND CHECK)

1. Check operation. Lightly oil the stem. Exercise the hand control and lightly oil the stem threads.
2. To clean and inspect the strainer screen in the water line to the control valve of the Ball Valve, close the incoming line gate valve, remove the screen, clean and inspect. Replace if necessary. Flush the line by momentarily opening the gate valve. Replace the screen and open the gate valve.

8.30E GLOBE VALVES

Operate globe valves to prevent sticking. Check valve for leakage. Replace discs if necessary. Lube stem and packing with one or two drops of oil.

8.30F BURIED VALVES

Operate inactive valves. Lubricate buried valves, if possible, by pouring oil down a pipe.

8.40C HYDRAULIC GATE OPERATOR

1. Periodically check tank fluid level. Level should be at the middle of the gauge. Check the system pressure. Inspect piping for leaks.

2. Replace hydraulic fluid. Drain the reservoir and fill to the middle of the sight gauge. Oil should be filtered and all containers, funnels, etc., clean. If equipped with pump and hydraulic motor cases with external drain connections, remove the plug (or tubed drain connection where there is no plug) and fill the case with hydraulic fluid. Then replace the plug. Clean suction strainers and replace filter elements.

A. CLEAN-INSPECT WATER TANK INTERIOR

Place motor switch in off position, and lock out the controls. Close the tank discharge gate valve. Open the tank drain gate valve and drain the tank. Remove the inspection cover and 8-inch blind flange on the opposite end of the tank. In large tanks that can be entered, install an electric fan or blower in the hole where the blind flange was removed. Purge the tank ten minutes before entering. Remove sand, clean and inspect the tank. Record amount of sand removed and condition of the tank. Remove the fan and reinstall the blind flange. Pour one gallon of chlorine solution into the tank. Replace the inspection cover, close the drain gate valve and put the unit back in service with the selector switch on automatic. Let the tank fill to its normal capacity, then let water and chlorine solution stand in tank for one-half hour. Drain and flush the tank until chlorine residual is below one-half mg/l. After this is accomplished, fill the tank with water and open the tank discharge gate valve.

B. WATER TANK MAINTENANCE

1. Check for leaks, water and air, all lines, valves, etc.

2. Check tank contents by the glass tube sight glass. Water level would be gauged by the length of the air relief valve line. Clean the sight glass tube if necessary. If the water tank is water logged, (too much water and not enough air), isolate the tank by closing the tank outlet valve. Turn the pump switch to off position. Open the tank drain valve and drain enough water out to leave the tank about 1/3 full of water. Close the drain valve and turn the pump switch to manual. When the pump starts, watch the check valve lever. When it shows the flow is full and continuous, shut off the pump and let it back spin. This draws air in through the inlet valve. As soon as the pump stops back spinning, start it again. This will force into the tank the air drawn in by the back spin. Continue this procedure until the proportion of air and water is correct. Open the tank outlet valve and place the switch on automatic. If there is a time clock on the well pump, reset the clock. If the proportion of air is too great, see Par. 8.10 C-2.

3. When leaks occur around the glass tube, renew the packing. Renew the paint stripe on the back of the glass tube if worn or faded. If sight gauge drain cock leaks, repair or replace.

9.01C STANDING WATER LEVEL

1. If there is an air line at the base of the water well pump motor frame with a water level gauge attached, remove the cap from the valve stem and attach a hand air pump. Pump air into the line until water level indicator hand stops rising and remains constant. Record the reading on the maintenance sheet.

2. To sound a well with battery operated equipment, use the following procedure. This equipment will have either one long and one short wire or two long wires taped together wound on a reel or drum, connected in series with a battery and ammeter. Remove the cap from the pipe into the well casing. If the equipment has a short wire, clamp this wire to metal for a ground. (Metal base plate or discharge pipe). Lower the long wire slowly through the pipe into the well casing. When the wire touches the water, this will complete the circuit through the ground and the ammeter hand will move. The same holds true with two wires. When they touch the water, the circuit will be complete through the two wires and the ammeter hand will move. Mark the wire with a piece of tape or string at the top, at the center of the discharge. Remove from the casing and measure from wire ends to the place you marked on the wire. If the wire has been previously marked as to footage, measure from the footage mark below your mark to your mark. The total being the standing water level or distance from the center of the discharge to the water. Always shut off and lock off the pump before sounding the well.

CHAPTER 8

EQUIPMENT MAINTENANCE

by

Lee Doty

EPA Review Notice

This chapter (as well as the entire manual) has been reviewed by the Office of Water Programs, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the Environmental Protection Agency, California State University, Sacramento, California Water Pollution Control Association, authors of the chapters or project reviewers and directors.

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OBJECTIVES

CHAPTER 8. EQUIPMENT MAINTENANCE

After completion of Chapter 8 you should be able to do the following.

1. Recognize the serious consequences that could occur when inexperienced, unqualified or unauthorized persons attempt to trouble shoot or repair electrical panels, controls, circuits, wiring or equipment.
2. Communicate with electricians by indicating possible causes of problems in electrical panels, controls, circuits, wiring and motors.
3. Properly select and use the following pieces of equipment (if qualified and authorized):
   a. Voltage tester
   b. Ammeter
   c. Megger
   d. Ohm meter.
4. Describe how a pump is put together.
5. Discuss the application or use of different types of pumps.
6. Maintain the various types of pumps.
7. Operate and maintain a compressor.
8. Develop and conduct an equipment lubrication program.

ATTENTION

I. DO NOT ATTEMPT TO INSTALL, TROUBLE SHOOT, MAINTAIN, REPAIR OR REPLACE ELECTRICAL EQUIPMENT, PANELS, CONTROLS, WIRING OR CIRCUITS UNLESS YOU

   A. KNOW WHAT YOU ARE DOING,

   B. ARE QUALIFIED, AND

   C. ARE AUTHORIZED.

Section 8.2, Electrical Equipment Maintenance, is presented to provide you with an understanding and awareness of electricity. The purpose of the section is to help you provide electricians with the information they will need when you contact them and request their assistance.

II. Due to the wide variety of equipment and manufacturers in the wastewater collection field, detailed procedures for the maintenance of some types of equipment were very difficult to include in this chapter. Also manufacturers are continually improving their products and some details would soon be out of date. For details concerning the operation, maintenance and repair of a particular piece of equipment, refer to the engineer's O & M manual or contact the manufacturer.

GLOSSARY

ALTERNATING CURRENT (A.C.) ALTERNATING CURRENT

Periodic electrical current which has alternating positive and negative values.

AMPERAGE AMPERAGE

The strength of an electric current measured in amperes.

AMPERE AMPERE

The unit used to measure current strength. The current produced by an electromotive force of one volt acting through a resistance of one ohm.

CAVITATION (CAV-i-TAY-shun) CAVITATION

The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.

CIRCUIT CIRCUIT

The complete path of an electric current, including the generating apparatus or other source, or a specific segment or section of the complete path.

CIRCUIT BREAKER CIRCUIT BREAKER

A safety device in an electrical circuit that automatically shuts off the circuit when it becomes overloaded. Device can be manually reset.

CONDUCTOR CONDUCTOR

A substance, body, device or wire that readily conducts or carries electricity.

COULOMB COULOMB

A measurement of the amount of an electrical charge conveyed by an electric current of one ampere in one second. 1 coulomb equals about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons).

CURRENT CURRENT

A movement or flow of electricity.

Water flowing in a pipe is measured in gallons per second past a certain point, not by the number of water molecules going past a point. Electric current is measured by the number of coulombs per second flowing past a certain point in a conductor. A coulomb is equal to about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons). A flow of 1 coulomb per second is called 1 ampere, the unit of the rate of flow of current.

DIRECT CURRENT (D.C.) DIRECT CURRENT

Electrical current flowing in one direction only and essentially free from pulsation.

ELECTROMOTIVE FORCE (E.M.F.) ELECTROMOTIVE FORCE

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See VOLTAGE.

ELECTRON ELECTRON

A very small, negatively-charged particle which is practically weightless. According to the electron theory, all electrical and electronic effects are caused either by the movement of electrons from place to place or because there is an excess or lack of electrons at a particular place.

FUSE FUSE

A protective device having a strip or wire of fusible metal which, when placed in a circuit, will melt and break the electrical circuit when subjected to an excessive temperature. This temperature will develop in the fuse when a current flows through the fuse in excess of that which the circuit will carry safely.

HERTZ (HURTS) HERTZ

Number of complete electromagnetic cycles or waves in one second of an electrical or electronic circuit. Also called the frequency of the current. Abbreviated HZ.

LEAD (LEE-d) LEAD

A wire or conductor that can carry electricity.

MANDREL (MAN-drill) MANDREL

A special tool used to push bearings in or to pull sleeves out.

MEGGER (from "megohm") MEGGER

An instrument used for checking the insulation resistance on motors, feeders, buss bar systems, grounds, and branch circuit wiring.

OHM OHM

The unit of electrical resistance. The resistance of a conductor in which one volt produces a current of one ampere.

POLE SHADER POLE SHADER

Separations on the iron core inside the coil of a magnetic starter.

RESISTANCE RESISTANCE

That property of a conductor or wire that opposes the passage of a current, thus causing electrical energy to be transformed into heat.

SHEAVE (SHE-v) SHEAVE

V-belt drive pulley which is commonly made of cast iron or steel.

SHIM	SHIM

Thin metal sheets which are inserted between two surfaces to align or space surfaces correctly. Can be used anyplace where a spacer is needed. Usually shims are 0.001 to 0.020 inches thick.

VOLTAGE	VOLTAGE

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See ELECTROMOTIVE FORCE (E.M.F.)

CHAPTER 8. EQUIPMENT MAINTENANCE

(Lesson 1 of 4 Lessons)

8.1 BEWARE OF ELECTRICITY

RECOGNIZE YOUR LIMITATIONS

In the wastewater collection and treatment maintenance departments of all cities, there is a need for maintenance workers to know something about electricity. Duties could range from repairing a tail light on a trailer or vehicle to repairing complex pump controls and motors. Very few maintenance workers do the actual electrical repairs or trouble shooting because this is a highly specialized field and unqualified people can seriously injure themselves and damage costly equipment. For these reasons you must be familiar with electricity, know the hazards, and recognize your own limitations when you must work with electrical equipment.

Most municipalities employ electricians or contract with a "commercial electrical company" that they call when major problems occur. However, the maintenance worker should be able to explain how the equipment is supposed to work and what it is doing or is not doing when it fails.

After this lesson you should be able to tell an electrician what appears to be the problem with electrical panels, controls, circuits, and equipment.

The need for safety should be apparent. If proper safe procedures are not followed in operating and maintaining the various electrical equipment used in wastewater collection and treatment facilities, accidents can happen that cause injuries, permanent disability, or loss of life. Some of the serious accidents that have happened and could have been avoided, occurred when machinery was not shut off, locked out, and tagged properly (Fig. 8.1). Possible accidents include:

1. Maintenance worker could be cleaning pump and have it start, thus losing an arm, hand, or finger.
2. Electrical motors or controls not properly grounded could lead to possible severe shock, paralysis, or death.
3. Improper circuit; such as, wrong connection, safety devices jumpered, wrong fuses, or improper wire. These mistakes can cause fires or injuries due to incorrect operation of machinery.

Another consideration for having a basic working knowledge of electricity is to prevent financial losses resulting from motors burning out and from damage to equipment, machinery and control circuits. Additional costs result when damages have to be repaired, including payments for outside laobr.

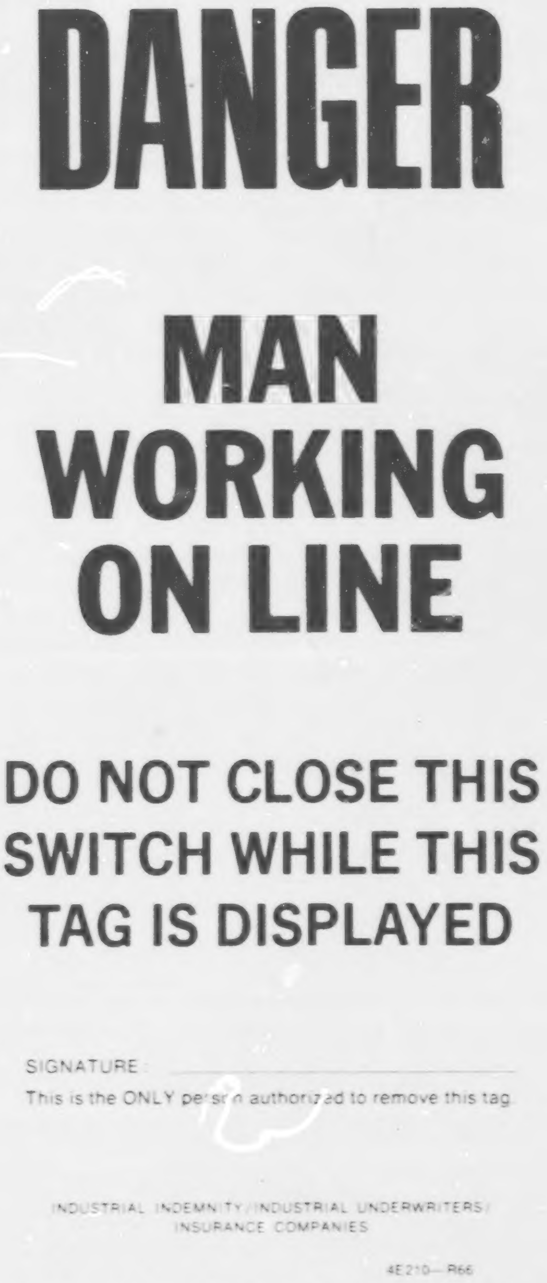
WARNING

Never touch electrical panels, controls, circuits, wiring or equipment unless you are qualified and authorized. By the time you find out what you don't know about electricity, you could find yourself too DEAD to use the knowledge.

QUESTIONS

8.1A Why must unqualified or inexperienced people be extremely careful when attempting to trouble shoot or repair electrical equipment?

8.1B What could happen when machinery is not shut off, locked out, and tagged properly?



DANGER

MAN
WORKING
ON LINE

DO NOT CLOSE THIS
SWITCH WHILE THIS
TAG IS DISPLAYED

SIGNATURE: ______________________
This is the ONLY person authorized to remove this tag.

INDUSTRIAL INDEMNITY/INDUSTRIAL UNDERWRITERS/
INSURANCE COMPANIES

4E210—R66

NOTE: Tag also should include: TIME OFF__________
DATE______________

Fig. 8.1. Typical warning tag.

(Source: Industrical Indemnity/Industrial Underwriters/Insurance Cos.)

8.2 ELECTRICAL EQUIPMENT MAINTENANCE

8.21 Introduction

This section contains a basic introduction to electrical terms and information plus directions on how to trouble shoot problems with electrical equipment.

Most electrical equipment used in wastewater collection systems and treatment plants is labeled with name plate information indicating the proper voltage and allowable current in amps.

8.22 Volts, Amps, Watts and Power Requirements

Volts:

Voltage (E) is also known as Electromotive Force (E.M.F.), and is the electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed.[1] This statement can be compared with the pressure or force that causes water to flow in a pipe. Some pressure in a water pipe is required to make the water move. The same is true of electricity. A force is necessary to push electricity or electric current through a wire. This force is called, Voltage.

There are two types of Voltage: Direct Current (D.C.) and Alternating Current (A.C.).

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[1] Electricians often talk about closing an electrical circuit. This means they are closing a switch that actually connects circuits together so electricity can flow through the circuit. Closing an electrical circuit is like opening a valve on a water pipe.

Direct Current

Direct Current (D.C.) is flowing in one direction only and is essentially free from pulsation. Direct current is seldom used in lift stations and wastewater treatment plants except in motor-generator sets, some control components of pump drives and stand-by lighting. Direct current is used exclusively in automotive equipment, certain types of welding equipment, and a variety of portable equipment. Direct current is found in various voltages, such as, 6 volts, 12 volts, 24 volts, 48 volts, and 110 volts. All batteries are direct current. D.C. is tested by holding the volt meter leads on the positive and negative poles on a battery. These poles are usually marked Positive (+), and Negative (-). Direct current usually is not found in higher voltages (over 24 volts) around plants and lift stations unless in motor-generator sets. Care must be taken when installing battery cables and wiring that Positive (+) and Negative (-) poles are connected properly to wires marked (+) and (-). If not properly connected, you could get an arc across the unit that could cause an explosion.

Alternating Current

Alternating Current (A.C.) is periodic current which has alternating positive and negative values. In other words, it goes from zero to maximum strength, back to zero and to the same strength in the opposite direction which comprises a cycle. Our A.C. voltage is 60-cycle frequency, or "Hertz", which means that this happens 60 times per second. Alternating current is classified as:

a. Single Phase
b. Two Phase
c. Three Phase
d. Poly Phase.

The most common of these are single phase and three phase. The various voltages you probably will find on your job are 110 volts, 120 volts, 208 volts, 220 volts, 240 volts, 277 volts, 440 volts, 480 volts, and 550 volts.

Single-phase power is found in lighting systems, small pump motors, various portable tools and throughout our homes. It is usually 120 volts or 240 volts. Single phase means that only one phase of power is supplied to the main electrical panel at 240 volts and has three wires or leads. Two of these leads have 120 volts each, the other lead is neutral and usually is coded white. The neutral lead is grounded. Many appliances and power tools have an extra ground (commonly a green wire) on the case for additional protection.

Three-phase power is generally used with motors and transformers found in lift stations and wastewater treatment plants. This power generally is 208, 220, 240 volts, or 440, 460, 480 and 550 volts. Higher voltages are used in some lift stations. Three phase is used when higher power requirements or larger motors are used because efficiency is usually higher and motors require less maintenance. Generally all motors above two horsepower are three phase unless there is a problem with the power company getting three phase to the installations. Quite a few residential lift stations are on single-phase power due to their remote locations. Three-phase power usually is brought in to the point of use with three leads.

There is power on all three leads and the fuse switches will generally appear as shown in Figure 8.2.

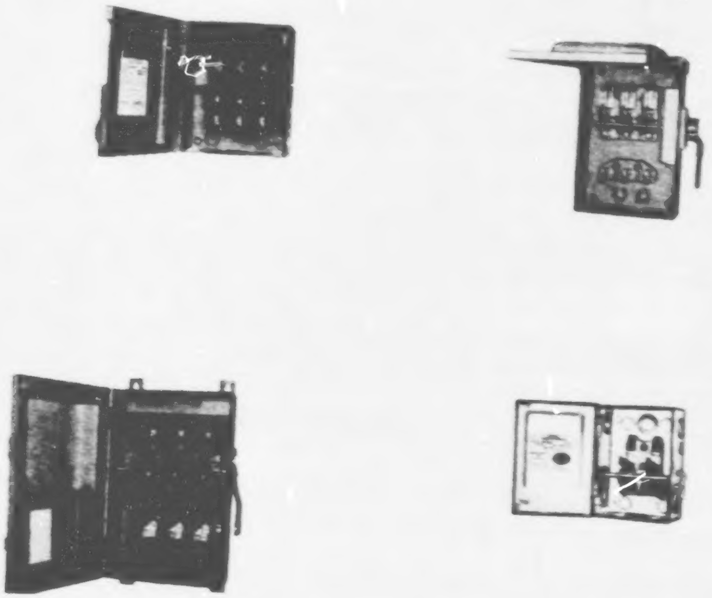


Fig. 8.2. Fuse switches.
(Courtesy of Consolidated Electrical Distributors, Inc.)

When taking a voltage check between any two of the three leads, you measure 208, 220, 240 volts, or 440, 460, 480 volts. There are some instances where you might measure a difference between the leads due to the use of different transformers.

If there is power in three leads and if a fourth lead is brought in, it is a neutral lead. Incoming power goes through a meter and then some type of disconnecting switch. This switch could be a fuse switch or a circuit breaker. The purpose of the disconnect switch is to open whenever a short or fault occurs and thus protect both the electrical circuits and electrical equipment.

Circuit breakers (Fig. 8.3) are used to protect electrical circuits from overloads. Most circuit breakers are metal conductors that de-energize the main circuit when excess current passes through a metal strip which becomes over heated and opens the main circuit.

Two-phase and poly-phase systems will not be discussed because they generally are not found in wastewater collection and treatment facilities.

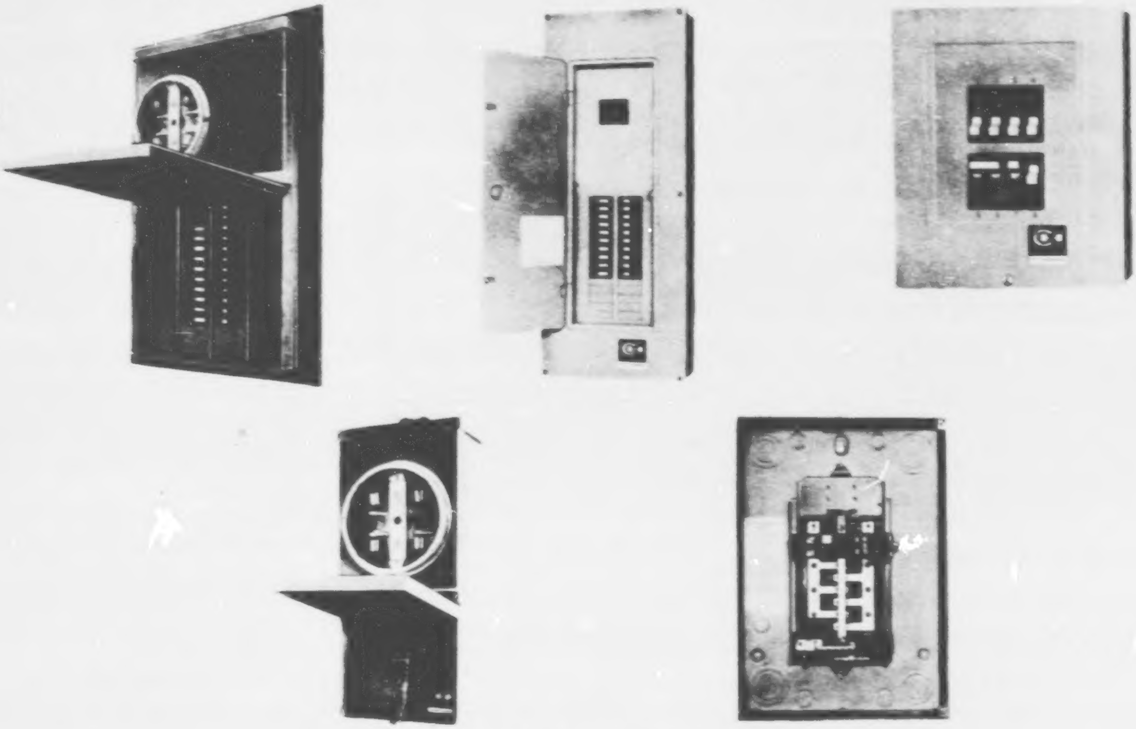


Fig. 8.3. Circuit breakers.

(Courtesy of Consolidated Electrical Distributors, Inc.)

Amps

An Ampere (I) is the practical unit of electric current. This is the current produced by a pressure of one volt in a circuit having a resistance of 1 ohm. Amperage is the measurement of current or electron flow and is an indication of work being done or "how hard the electricity is working."

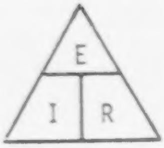
In order to understand amperage, one more term must be explained. The ohm is the practical unit of electrical resistance (R). "Ohm's Law" states that in a given electrical circuit the amount of current (I) in amperes is equal to the pressure in volts (E) divided by the resistance (R) in ohms. The following three formulas are given to provide you with an indication of the relationships among current, resistance and EMF.

$$\text{Current, amps} = \frac{\text{EMF, Volts}}{\text{Resistance, ohms}} \qquad \left(I=\frac{E}{R}\right)$$

$$\text{EMF, Volts} = (\text{Current, amps})\,(\text{Resistance, ohms}) \qquad (E=IR)$$

$$\text{Resistance, ohms} = \frac{\text{EMF, Volts}}{\text{Current, amps}} \qquad \left(R=\frac{E}{I}\right)$$

These equations are used by electrical engineers for calculating circuit characteristics. If you memorize the following relationship, you can always figure out the correct formula.

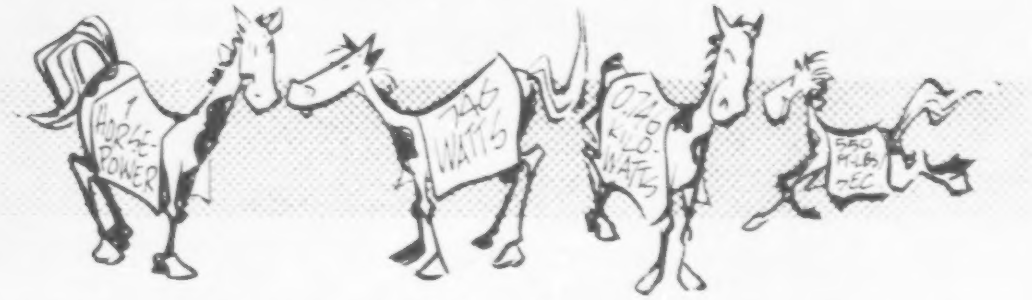


Watts

The watt and kilowatt (one thousand watts) are measures of power units used to rate electrical machines or motors or to indicate power in an electrical circuit. The watts or power (P) required by a machine is obtained by multiplying the amps (I) required or pulled times the potential drop in volts (E) or the electromotive force (EMF). The amount of watts in a circuit is equal to the voltage (E) times the amperage (I). The total power in a circuit, measured in watts, at any given moment is similar to the power produced by a motor at any given moment in horsepower.

Power, watts = (Electromotive Force, volts) (Current, amps)

or P, watts = (E, volts) (I, amps)



For the sake of comparisons

1 horsepower = 746 watts = 0.746 kilowatts = 550 ft-lbs/sec

The actual horsepower output of a motor also depends on the power factor (a number less than one) and the efficiency of the motor.

$$\text{Output, hp} = \frac{(\text{P, watts})(\text{Power factor})(\text{Efficiency})}{\text{746 watts/horsepower}}$$

Power Requirements

Power requirements (Pr) are expressed in kilowatt hours. 500 watts for two hours or one watt for 1000 hours equals one kilowatt hour. The power company charges so many cents per kilowatt hour.

Power req, kw-hr = (Power, kilowatts) (Time, hours)

Pr, kw-hr = (P, kw) (T, hr)

Conductors and Insulators

A material, like copper, which permits the flow of electrical current is called a conductor. Material which will not permit the flow of electricity, like rubber, is called an insulator. Such material when wrapped or cast around a wire is called insulation. Insulation is commonly used to prevent the loss of electrical flow by two conductors coming into contact with each other.

QUESTIONS

8.22A What are the two types of voltage?

8.22B Amperage is a measurement of what?

8.22C How can you determine the proper voltage and allowable current in amps for a piece of equipment?

8.23 Tools, Meters and Testers (Fig. 8.4)

WARNING

Never enter an electrical panel or attempt to trouble shoot or repair any piece of electrical equipment or any electrical circuit unless you are qualified and authorized.

In order to maintain, repair, and trouble shoot electrical equipment and circuits, the proper tools are required. In order to check for "VOLTAGE", a voltage tester is needed. There are several types on the market and all of them work. They are designed to be used on energized circuits and care must be exercised when testing. By holding one lead on ground and the other on a power lead, you can determine if power is available. You also can tell if it is A.C. or D.C. and the intensity or voltage (110, 220, 480, or whatever) by testing the different leads.

Do not work on any electrical circuits unless you are qualified and authorized. Use a voltage tester and other circuit testers to determine if circuit is energized, or if all voltage is off. This should be done after the main switch is turned off to make sure

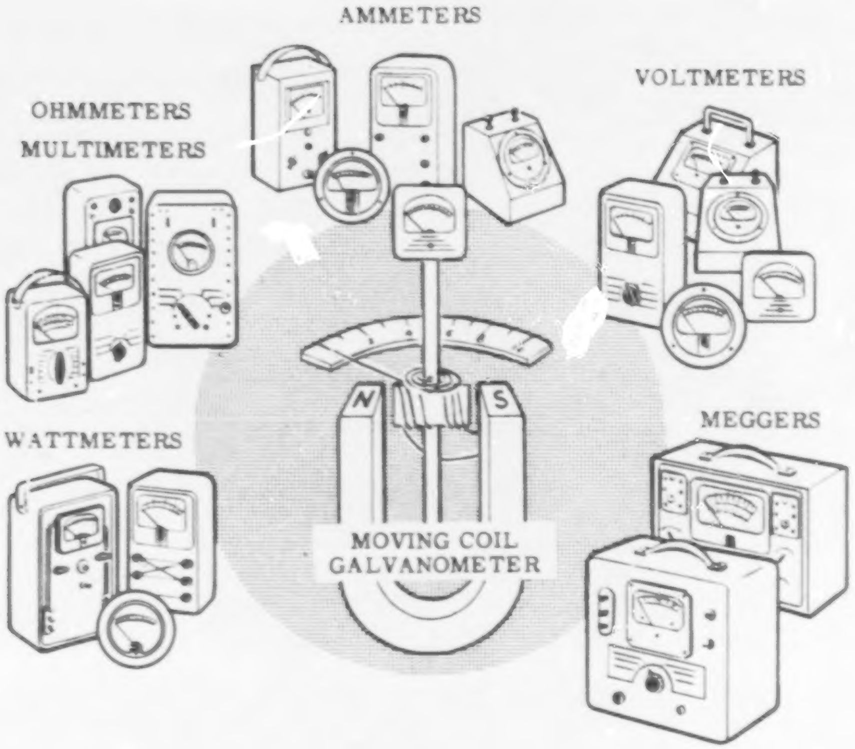

AMMETERS
VOLTMETERS
OHMMETERS
MULTIMETERS
N
S
MEGGERS
WATTMETERS
MOVING COIL
GALVANOMETER

Fig. 8.4. Electrical meters.

"From 1st Edition of Basic Electricity, Volumes 1-5
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it is safe to work inside the electrical panel. Always be aware of the possibility that even if the disconnect to the unit you are working on is off, the control circuit may still be energized if the circuit originates at a different distribution panel. Check voltage tester before and during time switch is pulled off to have a double check. This procedure insures that the voltage tester is working and that you have good continuity to your tester. Use circuit testers to measure voltage or current characteristics to a given piece of equipment for making sure that you have or do not have a "live" circuit.

Besides using the voltage tester for checking power, it can be used to test for open circuits, blown fuses, single phasing of motors, grounds, and many other uses. Some examples are illustrated in the following paragraphs.

In the circuit shown below (Figure 8.5), test for power by holding one lead of the tester on point "A", and the other at point "B". If no power is indicated, the switch is open or faulty. Sketch shows switch in "open" position.

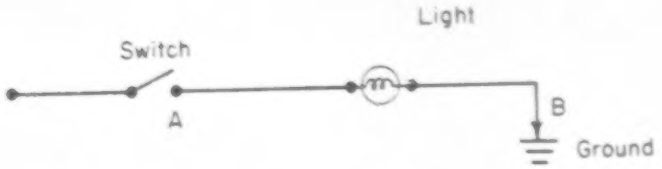

Fig. 8.5. Single-phase circuit.

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To test for power at Point "A", and Point "B" in Figure 8.6, open the switch as shown. Using a volt meter or voltage tester with clamp-on leads, clamp a lead on L1 and a lead on L2 between the fuses and the load. Bring the voltage tester and leads out of the panel and close the panel door as far as possible without cutting or damaging the meter leads. Some switches cannot be closed if the panel door is open. The panel door is closed when testing because hot copper sparks could seriously injure you when the circuit is energized and the voltage is high. Close the switch.

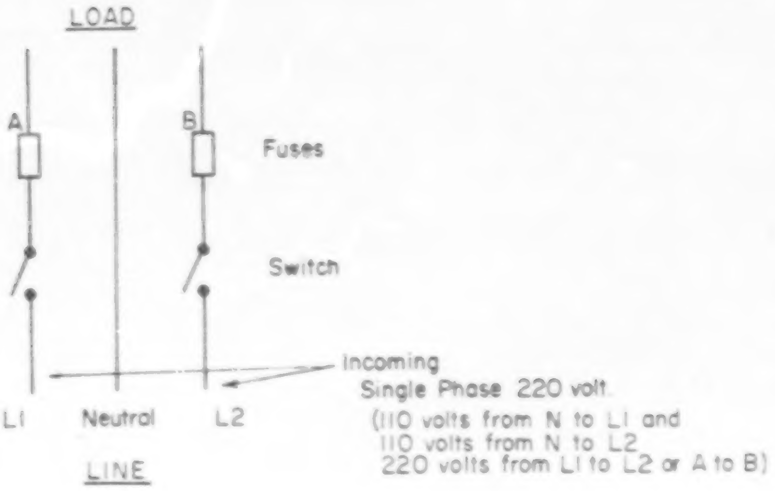
LOAD
A
B
Fuses
Switch
Incoming
Single Phase 220 volt
(110 volts from N to L1 and
110 volts from N to L2
220 volts from L1 to L2 or A to B)
L1
Neutral
L2
LINE

Fig. 8.6. Single-phase, three lead circuit.

1. Voltage tester should register at 220 volts. If there is no reading at points "A" and "B", the fuse or fuses could be "blown".

2. Move voltage tester down below fuses to line 1 and line 2 (L1, L2). If there is still no reading on the voltage tester, check for an open switch in another location, or call the power company to find out if power is out.

3. If a 220 volt reading is registered at line 1 and line 2, move the test leads to point "A", and the "neutral" lead. If a reading of 110 volts is observed, the fuse on line "A" is okay. If there isn't a voltage reading, the fuse on line "A" is "blown". Move the lead from line "A" to line "B". Observe the reading. If 110 volt power is recorded, the fuse on line "B" is okay. If no power is registered, the fuse on line "B" is "blown". Another possibility to consider is that the neutral line could be broken. Under these conditions, if there is voltage on line "A" and the fuse on line "B" is blown, voltage will appear on line "B".

> WARNING - Turn off power and be sure that there is no voltage in either power line before changing fuses. Use a Fuse Puller. Test circuit again in the same manner to make sure fuses or circuit breakers are okay. 220 volts power or voltage should be present between point "A" and "B". If fuse or circuit breaker trips again, shut off and determine the source of the problem.

Test for power at points "A", "B" and "C" in three-phase circuit (Figure 8.7). Place voltage tester leads on lines "A" and "B". Close all switches. 220 volts should register on voltage tester. Check between lines "A" and "C", and between lines "B" and "C". 220 volts should be recorded between all of these points. If voltage is not present, one or all of the fuses are "blown" or the circuit breaker tripped. First check for voltage above the fuses at all of these points, "A" to "B", "A" to "C", and "B" to "C", to make sure power is available (See 220 readings in Figure 8.7). If voltage is recorded, move leads back down to bottom of fuses. If voltage is present from "A" to "B", but not at "A" to "C", and "B" to "C", the fuse on line "C" is "blown". If there weren't any voltage readings at any of the test points, all the fuses could be "blown".

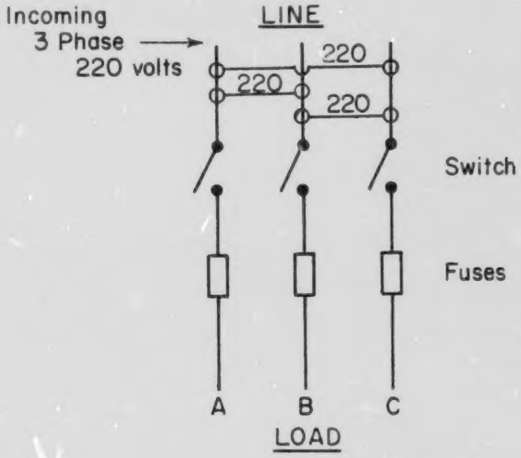

Fig. 8.7. Three-phase circuit, 220 volts.

Another way of checking the fuses on this three-phase circuit would be to take your voltage tester and place one lead on the bottom, and one lead on the top of each fuse. You should not get a voltage reading on the voltmeter. This is because electricity takes the path of least resistance. If you get a reading across any of the fuses (top to bottom), that fuse is bad.

Always make sure that when you use a voltmeter it is set for the proper voltage. If voltage is unknown and the meter has different scales that are manually set, always start with the highest voltage range and work down. Otherwise the voltmeter could be damaged. Look at the equipment instruction manual or name plate for the expected voltage. Actual voltage should not be much higher than given unless someone goofed when the equipment was wired and inspected.

Voltage readings are important because they determine how you connect motor leads, relays, and transformers. Low or high voltages can drastically affect motors.

Another meter used in electrical maintenance and testing is the Ammeter. The ammeter records the current or "amps" in the circuit. There are several types of ammeters, but only two will be discussed in this chapter. The ammeter generally used for testing is called a "clamp on" type. The term "clamp on" means that it can be clamped around a lead or each lead supplying a motor lead, and no direct electrical connection need be made. These are used by clamping the meter over only one of the power leads to the motor or other apparatus and taking a direct reading. Each "leg" or lead on a three-phase motor must be checked by itself.

The first step should be to read the motor name plate data and find what the amperage reading should be for the particular motor or device you are testing. After you have this information, set the ammeter to the proper scale. Set it on a higher scale than necessary if the expected reading is close to the top of the meter scale. Place the clamps around one lead at a time. Record each reading and compare with the name plate rating. If the readings don't compare with the name plate rating, find the cause, such as low voltage, bad bearings, poor connections, plugging or excessive load. If the ammeter readings are higher than expected, the high current could produce overheating and damage the equipment. Try to find the problem and correct it.

When using a clamp on ammeter, be sure to set the meter on a high enough range or scale for the starting current if you are testing during start up. Starting currents range from 110 to 150 percent higher than running currents and using too low a range can ruin an expensive and delicate instrument. Newer clamp on ammeters automatically adjust to the proper range and can measure both starting or peak current and normal running current.

Another type ammeter is one that is connected in line with the power lead or leads. Generally they are not portable and are usually installed in a panel or piece of equipment. They require physical connections to put them in series with the motor or apparatus being tested. These ammeters are usually more accurate than the "clamp on" type and are used in motor control centers and pump panels.

A Megger is used for checking the insulation resistance on motors, feeders, buss bar systems, grounds, and branch circuit wiring.

WARNING

Turn off circuit breaker when using a Megger.

There are three general types of Meggers: crank operated, battery operated, and instrument. There are two leads to connect. One lead is clamped to a ground lead, and the other to the lead you are testing. The readings on the Megger will range from "0" (ground) to Infinity (perfect), depending on the condition of your circuit.

The megger is usually connected on the motor terminals, one at a time, at the starter, and the other lead to the ground lead. Results of this test indicate if the insulation is deteriorating or cut.

If a low reading is obtained, disconnect motor leads from power or line leads. Meg motor and if low reading is observed, the motor winding insulation is breaking down. If a good reading is obtained, meg the circuit or branch wiring. If this reading is low, the wiring to the motor is bad. A rule of thumb to use is that you should not run a motor if it is less than one megohm[2] per horsepower. This means a 5 horsepower motor should have a 5 megohm reading; 10 horsepower, a 10 megohm reading; 20 horsepower, 20 megohm reading; and so forth.

Motors and wirings should be megged at least once a year, and twice a year if possible. The readings taken should be recorded and plotted in some manner so that it can be determined when insulation is breaking down. Meg motors and wirings after a pump station has been flooded. If insulation is wet, excessive current could be drawn and cause pump motors to "kick out."

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[2] Megohm. Meg means one million, so 5 megohms means 5 million ohms. A Megger reads in millions of ohms.

OHM Meters, sometimes called circuit testers, are valuable tools used for checking electrical circuits. An ohm meter is used only when the electrical circuit is OFF, or de-energized. The ohm meter supplies its own power by using batteries. An ohm meter is used to measure the resistance (ohms) in a circuit. These are most often used in testing the control circuit components such as coils, fuses, relays, resistors, and switches. They are used also to check for continuity. An ohm meter has several scales which can be used. Typical scales are: R x 1, R x 10, R x 1,000, and R x 10,000. Each scale has a level of sensitivity for measuring different resistances. To use an ohm meter, set the scale, start at the low point (R x 1), and put the two leads across the part of the circuit to be tested such as a coil or resistor and read the resistance in ohms. A reading of infinity would indicate an open circuit, and a "0" would read no resistance. These usually would be used only by skilled technicians because they are very delicate instruments.

All meters should be kept in good working order and calibrated periodically. They are very delicate, susceptible to damage, and should be well protected during transportation. When readings are taken, they should always be recorded on a machinery history card for future reference. Meters are a good way to determine pump and equipment performance. Never use a meter unless qualified and authorized.

QUESTIONS

8.23A How can you determine if there is voltage in a circuit?

8.23B What are some of the uses of a voltage tester?

8.23C What precautions should be taken before attempting to change fuses?

8.23D How do you test for voltage with a voltmeter when the voltage is unknown?

8.23E What could be the cause of amp readings different from the name plate rating?

8.23F How often should motors and wirings be megged?

8.23G An ohm meter is used to check the ohms of resistance in what control circuit components?

8.24 Equipment Protective Devices

Electricity like anything else needs safety devices to protect workers and equipment. Water systems have pressure valves, pop offs and different safety equipment to protect the pipes and equipment. So must electricity have safety devices to contain the voltage and amperage that comes in contact with the wiring and equipment. The first piece of equipment which must be protected is the main electrical panel or control unit where the power enters. This protection is accomplished by one of two ways: fusing or installing a main circuit breaker.

Let's start with fuses (Fig. 8.8). The power company has installed fuses on their power poles to protect their equipment from damage. We also must install something to protect the main control panel and wiring from damage due to excessive voltage or amperage.

A fuse is a protective device having a strip or wire of fusible metal which, when placed in a circuit, will melt and break the electricial circuit when subjected to an excessive temperature. This temperature will develop in the fuse when a current flows through the fuse in excess of what the circuit will carry safely. This means that the fuse must be capable of de-energizing the circuit before any damage is done to the wiring it is safely protecting. Fuses are used to protect workers, main circuits, branch circuits, heaters, motors, and various other electrical equipment.

There are several types of fuses, each being used for a certain type of protection. Some of these are:

1. Current limiting fuses: Used to protect against current in circuits.
2. Dual element fuses: Used for motor protection.
3. Time delay fuses: Used in electronic and motor starting circuits.
4. Sand filled fuses: Used on high voltage.
5. Phase fuses: Used to protect phase sequence.
6. Voltage sensitive fuses: Used where close voltage control is needed.

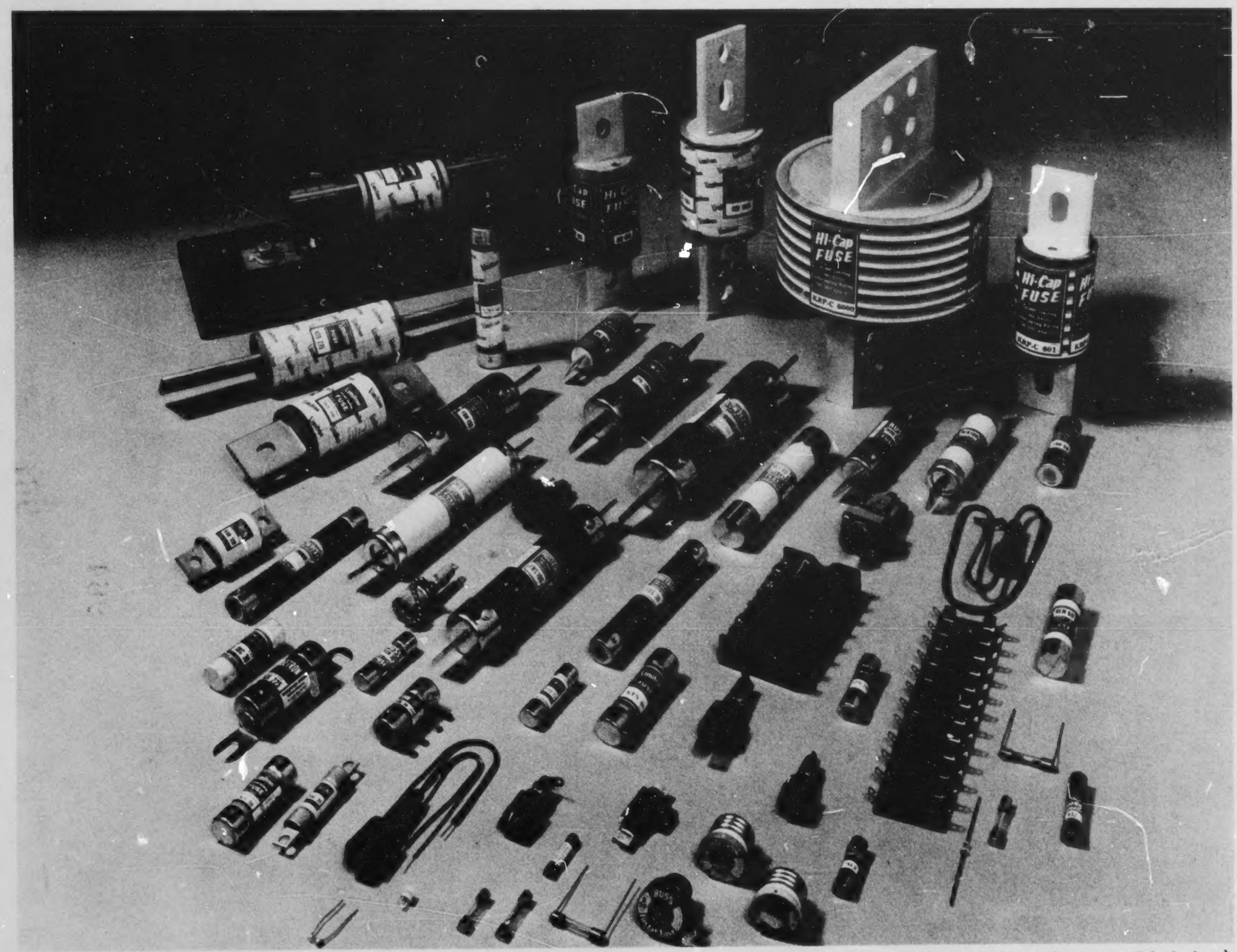
Hi-Cap FUSE
KRP-C 6000
Hi-Cap FUSE
KRP-C 601
BUSS

Fig. 8.8. Fuses. (Courtesy of Bussmann Manufacturing, McGraw-Edison Company Division)

There are many other types of fuses used for special application, but the above are the most common.

A fuse must never be by-passed or jumped. This is the only protection the circuit has; and without it, serious damage to equipment and possible injury to workers can occur. Make sure that all fuses are replaced with the proper size and type indicated for that circuit. If you have any doubt, check the electrical prints or contact your electrical engineer.

The circuit breaker (Fig. 8.3) is another safety device and is used in the same places as a fuse. Most circuit breakers consist of a switch that opens automatically when the current or the voltage exceeds or falls below a certain limit. Unlike a fuse that has to be replaced each time it "blows", a circuit breaker can be reset after a short delay to allow time for cooling. This is done by moving the handle to the "off" position or slightly past, and then moving it back to the "on" position. Also, unlike a fuse, a circuit breaker can be visually inspected to find out if it has been tripped. The handle will be at the mid position between "on" and "off". Several different types of circuit breakers are being used today and each one is selected for a special protective purpose.

Three-phase motors are usually protected by overload circuit breakers. This is accomplished by having heater strips, bimetal, or solder pots which open on current rise (overheating), and open the control circuit. This in turn opens the motor control circuit, which de-energizes the starter and stops power to the motor. These also are known as heaters or "thermal overloads". Sizing of these overloads is very critical and should coincide with the name plate rating on the motor. Overload circuit breakers should never be sized over 125% of the value on the motor name plate. Sizing depends on the service factor of the electric motor. Usually they range from 100% to 110% of the motor name plate ratings. For example, if the motor is rated for 10 amps, the overloads should be sized from 10 to 11 amps.

Again, never increase the rating of the overload heaters because of tripping. You should find the problem and repair it. There are many other protective devices for electricity such as motor winding thermostats, phase protectors, low voltage protectors, and ground fault protectors. Each has its own special applications and should never be tampered with or jumped. Different types of fuses are shown in Figure 8.8.

Ground is an expression representing an electrical connection to earth or a large conductor which is at the earth's potential or neutral voltage. Motor frames and all electrical tools and equipment enclosures should be connected to ground. This is generally referred to simply as grounding, or equipment ground.

The third prong on cords from electric hand tools is the equipment ground and must never be removed. When an adapter is used with a two-prong receptacle, the green wire on the adapter should be connected under the center screw on the receptacle cover plate. Many times equipment grounding, especially at home, is achieved by connecting onto a water pipe or drain rather than a rod driven into the ground. This practice generally is not recommended when plastic pipes and other non-conducting pipe materials are used unless it is known that the piping is all metal and not interrupted. Also corrosion can be accelerated if pipes of different metals are used. A rod driven into dry ground isn't very effective as a ground.

QUESTIONS

8.24A What are two types of safety devices found in main electrical panels or control units?

8.24B What are fuses used to protect?

8.24C Why must a fuse never be by-passed or jumped?

8.24D How does a circuit breaker work?

8.25 Motor Starters

A motor starter is a device or group of devices which are used to connect the electrical power to a motor. These starters can be either manually or automatically controlled.

Manual and magnetic starters range in complexity from a simple "on-off" switch, to a sophisticated automatic device using timers and coils. The simplest motor starter is used on single-phase motors where a circuit breaker is turned on and the motor starts. This type of starter also is used on three-phase motors of smaller horsepower. These are used on fan motors, machinery motors, and several others where it isn't necessary to have automatic control.

Magnetic starters (Fig. 8.9 and 8.10) are generally used to start pumps, compressors, blowers, and anything where automatic or remote control is desired. They permit low voltage circuits to energize the starter of equipment at a remote location or to start larger starters (Fig. 8.11). A magnetic starter is operated by electromagnetic action. It has contactors and these operate by energizing a coil which closes the contact, thus starting the motor. The circuit which energizes the starter is called the control circuit and it is usually operated on a lower voltage (115 volts) than the motor. Whenever a starter is used as a part of an integrated circuit (such as for flow, pressure or temperature control), a magnetic starter or controller is necessary.

Magnetic starters are sized for their voltage and horsepower ratings. These are divided into classes. The most common starter is Class "A". A Class "A" starter is an "Alternating Current Air-break and oil immersed manual, or magnetic controller for service on 600 volts or less. It is capable of interrupting operating overloads up to and including 10 times their normal motor rating, but not short circuits or faults beyond operating overloads."

Additional class information can be found in electrical catalogues, manuals and manufacturers' brochures.

8.26 Motors

Electric motors are the machines most commonly used to convert electrical energy into mechanical energy.

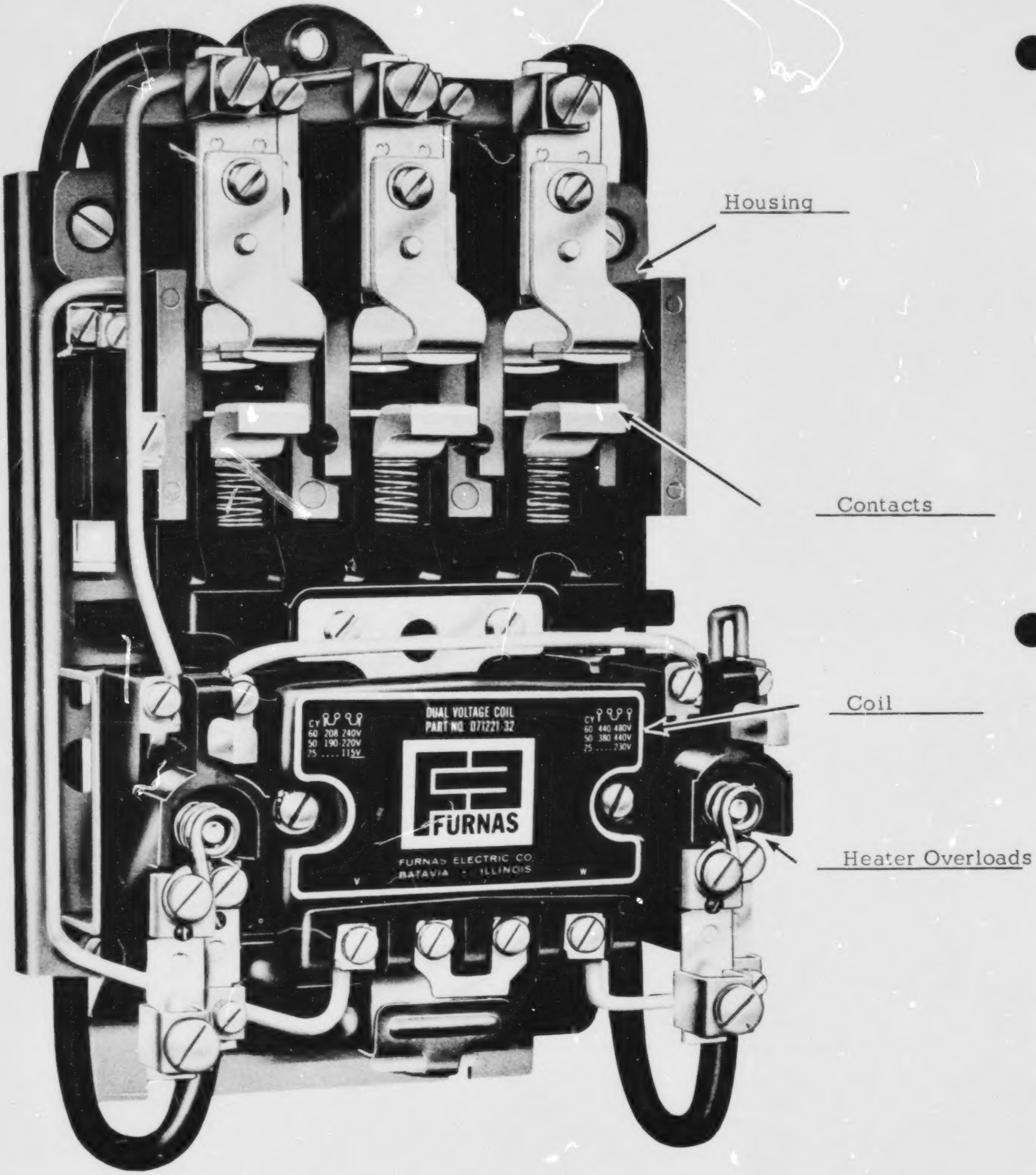
Housing
Contacts
Coil
Heater Overloads
DUAL VOLTAGE COIL
PART NO. 071221-32
FURNAS
FURNAS ELECTRIC CO.
BATAVIA ILLINOIS

Fig. 8.9. Three-phase magnetic starter.
(Courtesy of Furnas Electric Company)

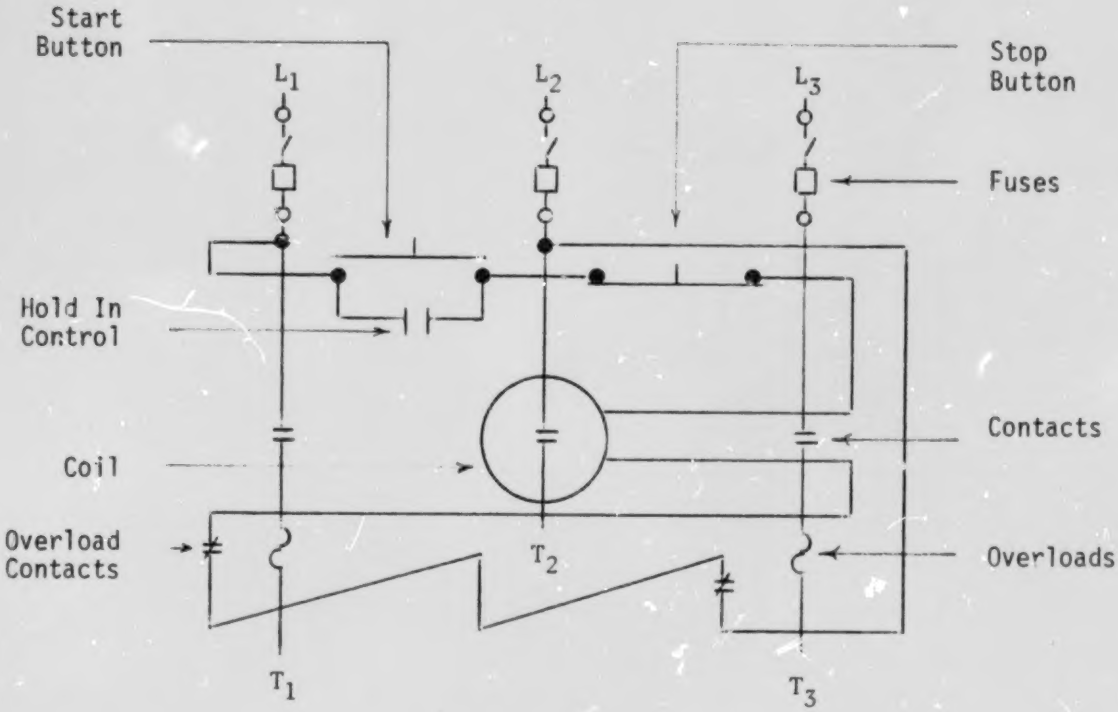
Start Button
L_1
L_2
L_3
Stop Button
Fuses
Hold In Control
Contacts
Coil
Overload Contacts
T_2
Overloads
T_1
T_3

Fig. 8.10. Wiring diagram of three-phase magnetic starter.

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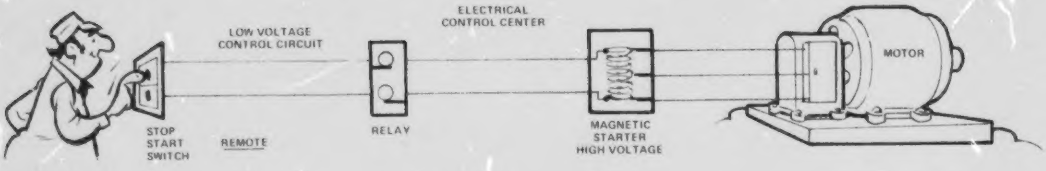


Fig. 8.11. Application of magnetic starter.

A motor usually consists of a stator, rotor, end bells[3], and windings. The rotor has an extending shaft which allows a machine to be coupled to it.

Motors are of many different types (Figure 8.12), such as, squirrel cage induction motors, wound rotor motors, synchronous motors and many others. The most common of these is the squirrel cage induction motor. Some pumping stations use wound rotor induction motors when speed control is needed.

Three-phase electric motors are used for operating pumps, compressors, grinders, fans and other machinery. Motors are generally trouble free and when lubricated properly cause very few problems. The amperage and voltage readings on motors should be taken periodically to insure proper operation.

Motors are classified by their design such as A, B, C, D, and F. Design B, the most frequently used motor, is the standard general purpose motor used where low locked rotor current and moderate locked rotor torque are required along with high full load rpm and efficiency.

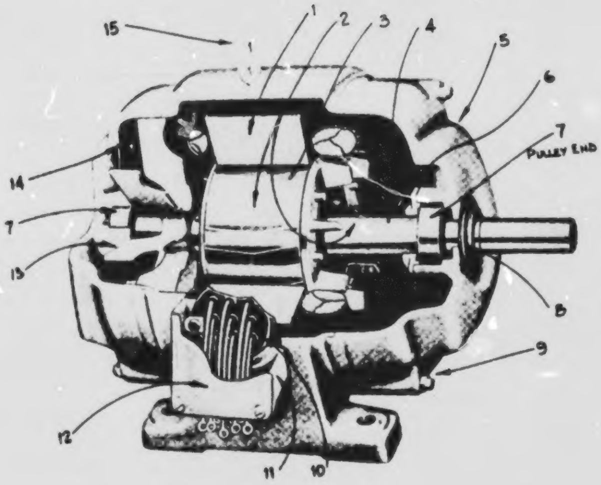
Another important consideration on a motor is the class of insulation. This determines how hot a motor may operate. This is listed as degree rise on the motor name plate (Figure 8.13).

---

[3] End bells. Devices used to hold the rotor and stator in position.

DRIP PROOF

ITEM NO.	PART NAME
1	Wound Stator w/ Frame
2	Rotor Assembly
3	Rotor Core
4	Shaft
5	Bracket
6	Bearing Cap
7	Bearings
8	Seal, Labyrinth
9	Thru Bolts/Caps
10	Seal, Lead Wire
11	Terminal Box
12	Terminal Box Cover
13	Fan
14	Deflector
15	Lifting Lug


15
1
1
2
3
4
5
6
7
Pulley End
14
7
13
8
9
12
11
10

TOTALLY ENCLOSED FAN COOLED

ITEM NO.	PART NAME
1	Wound Stator w/ Frame
2	Rotor Assembly
3	Rotor Core
4	Shaft
5	Brackets
6	Bearings
7	Seal, Labyrinth
8	Thru Bolts/Caps
9	Seal, Lead Wire
10	Terminal Box
11	Terminal Box Cover
12	Fan, Inside
13	Fan, Outside
14	Fan Grill
15	Fan Cover
16	Fan Cover Bolts
17	Lifting Lug

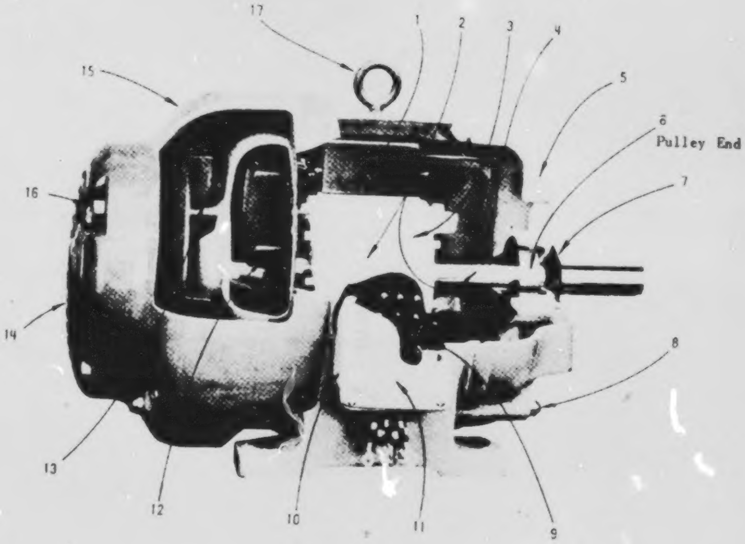
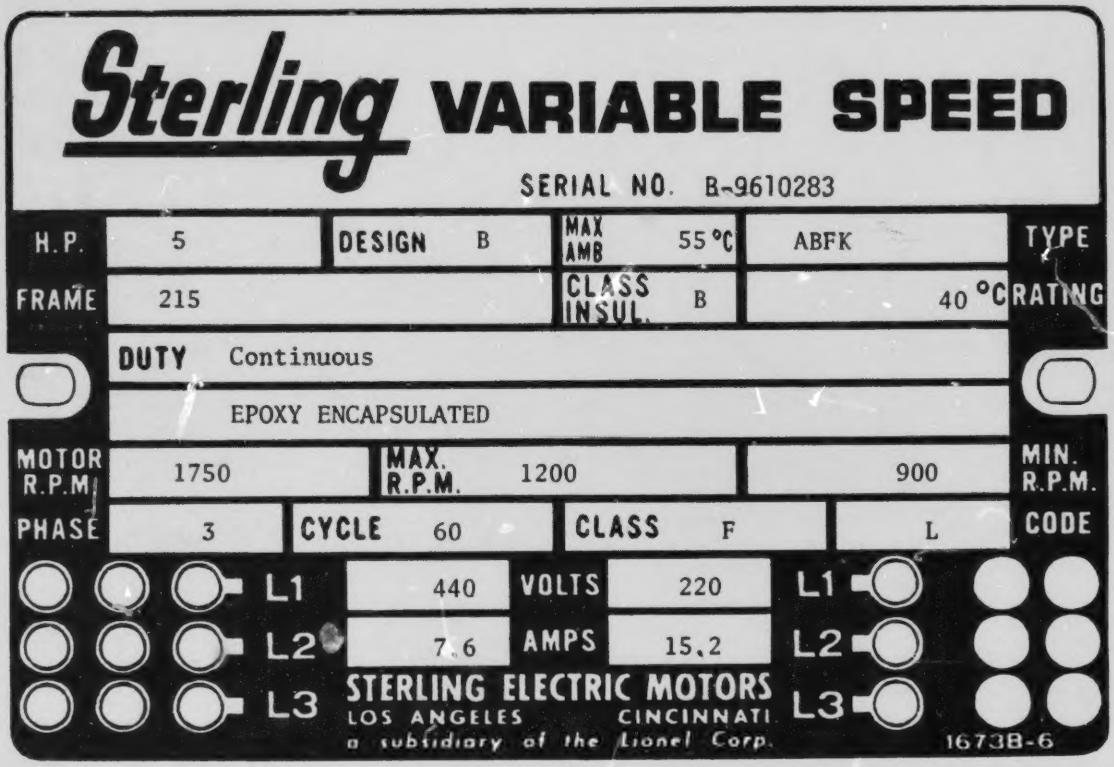

17
1
2
3
4
15
5
6
Pulley End
16
7
14
8
13
12
10
11
9

Fig. 8.12. Typical motors.
(Courtesy of Sterling Power Systems, Inc.)



Sterling VARIABLE SPEED

SERIAL NO. B-9610283

H.P.	5	DESIGN B	MAX AMB 55 °C	ABFK	TYPE
FRAME	215		CLASS INSUL. B	40 °C	RATING
	DUTY Continuous				
	EPOXY ENCAPSULATED				
MOTOR R.P.M.	1750	MAX. R.P.M. 1200		900	MIN. R.P.M.
PHASE	3	CYCLE 60	CLASS F	L	CODE

L1	440	VOLTS	220	L1
L2	7.6	AMPS	15.2	L2
L3				L3

STERLING ELECTRIC MOTORS
LOS ANGELES CINCINNATI
a subsidiary of the Lionel Corp.
16738-6

NOTE: 1. The motor for this unit is rated at 1750 RPM and the maximum speed for the variable drive unit is 1200 RPM.

2. The 40°C rating is the allowable operating temperature above ambient temperature.

Fig. 8.13. Typical name plate.
(Courtesy of Sterling Power Systems, Inc.)

Motor insulation classes are as follows:

Class	Temperature Rating
A	105°C (221°F)
B	130°C (266°F)
F	155°C (311°F)
H	180°C (356°F)

At present most motors are Class B insulated. Try to keep the actual operating temperature below the temperature rating or limit in order to prolong the life of the insulation.

All of this information can be found on the motor name plate and should be taken into consideration when evaluating a motor. Most of the trouble encountered with electrical motors result from bad bearings, shorted windings due to insulation breakdown or excessive moisture.

All of the information on the Motor Name Plate (Figure 8.13) should be recorded and placed in a file for future reference. Many times the name plate is painted, corroded or missing from the unit when the information is needed to repair the motor or replace parts. Record date of installation and service start up.

See Section 8.28, Records, for typical data sheet for recording the essential information. This information also should be on the manufacturer's data sheet and in the instruction manual. Compare the information for consistency and file. Be sure you have the correct serial and/or model numbers.

QUESTIONS

8.25A How are motor starters controlled?

8.25B When are magnetic starters used?

8.26A How is electrical energy converted into mechanical energy?

8.26B What are the important parts of an electric motor?

8.26C How can motors be kept trouble free?

8.26D What should be done with motor name plate data?

8.27 Trouble Shooting

Practical step-by-step procedures combined with a common sense approach is the key to effective trouble shooting.

"NEVER TAKE ANYTHING FOR GRANTED"

A. Gather preliminary information. The first step in trouble shooting any motor control which has developed trouble, is to understand the circuit operation and other related functions. In other words, what is supposed to happen, operate, and so forth when it's working right? Also what is it doing now? The qualified maintenance worker should be able to do the following:

1. Know what should happen when a switch is pushed: When switches are pushed or tripped, what coils go in, contacts close, relays operate, and motors run.
2. Examine all other factors: What other unusual things are happening in the lift station (facility) now that this circuit doesn't work properly? Lights dimmed, other pumps ran faster, lights went out when it broke, everything was flooded, workers were hosing down area, and many other possible factors.
3. Analyze what you know: What part of it is working correctly? Is switch arm tripped? Everything but this is alright, except pump gets plugged with rags frequently. Is it a mechanical failure or an electrical problem caused by a mechanical failure?
4. Select simple procedures: To localize the problem, select logical ways that can be simply and quickly accomplished.
5. Make a visual inspection: Look for burned wires, loose wires, area full of water, coil burned, contacts loose, or strange smells.
6. Converge on source of trouble: Mechanical or electrical. Motor or control, whatever it might be. Electrical problems result from some type of mechanical failure.

7. Pinpoint the problem: Exactly where is the problem and what do you need for repair?

8. Find the cause: What caused the problem? Moisture, wear, poor design, voltage, or overloading.

9. Repair the problem and eliminate the cause if possible. If the problem is inside switch gear or motors, call an electrician. Give the electrician the information you have regarding the equipment. Do not attempt electrical repairs unless qualified and authorized, otherwise you could cause excessive damage to yourself and to the equipment.

B. Some of the things to look for when trouble shooting are:

1. Contacts:

Trouble	Possible Cause	Remedy
Contact Chatter	1. Broken pole shader[4].	1. Replace.
	2. Poor contact in control circuit.	2. Improve contact or use holding circuit interlock.
	3. Low voltage.	3. Correct voltage condition. Check momentary voltage dip.

---

[4] Pole shader. Separations on the iron core inside the coil of a magnetic starter.

Trouble	Possible Cause	Remedy
Welding or Freezing	1. Abnormal surge of current	1. Use larger contactor and check for grounds, shorts, or excessive motor load current.
	2. Frequent jogging[5]	2. Install larger device rated for jogging service or caution operator.
	3. Insufficient contact pressure.	3. Replace contact spring; check contact carrier for damage.
	4. Contacts not positioning properly.	4. Check for voltage dip during start up.
	5. Foreign matter preventing magnet from seating.	5. Clean contacts.
	6. Short circuit.	6. Remove short fault and check that fuse or breaker are right.
Short contact life or overheating of tips	1. Contacts poorly aligned, spaced or damaged.	1. Do not file silver faced contacts. Rough spots or discoloration will not harm contacts.
	2. Excessively high currents.	2. Install larger device. Check for grounds, shorts, or excessive motor currents.
	3. Excessive starting and stopping of motor.	3. Caution operators. Check operating controls.
	4. Weak contact pressure.	4. Adjust or replace contact springs.
	5. Dirty contacts.	5. Clean with approved solvent.
	6. Loose connections.	6. Check terminals and tighten.

---

[5] Jogging. Starting and stopping.

Trouble	Possible Cause	Remedy
Coil, overheated	1. Starting coil may not kick out.	1. Repair coil.
	2. Overload won't let motor reach minimum speed.	2. Remove overload.
	3. Over voltage or high ambient temperature.	3. Check application and circuit.
	4. Incorrect coil.	4. Check rating and if incorrect, replace with proper coil.
	5. Shorted turns caused by mechanical damage or corrosion.	5. Replace coil.
	6. Undervoltage, failure of magnet to seal it.	6. Correct system voltage.
	7. Dirt or rust on pole faces increasing air gap.	7. Clean pole faces.
Overload Relays Tripping	1. Sustained overload.	1. Check for grounds, shorts or excessive motor currents. Mechanical overload.
	2. Loose connection on all or any load wires.	2. Check, clean, and tighten.
	3. Incorrect heater.	3. Replace with correct size heater unit.
	4. Fatigued heater blocks.	4. Inspect and replace.

Trouble	Possible Cause	Remedy
Failure to trip	1. Mechanical binding, dirt, or corrosion.	1. Clean or replace.
	2. Wrong heater, or heaters omitted and jumper wires used.	2. Check ratings. Apply heaters of proper rating.
	3. Motor and relay in different temperatures.	3. Adjust relay rating accordingly, or install temperature compensating relays.

2. Magnetic and Mechanical Parts

Trouble	Possible Cause	Remedy
Noisy magnet (humming)	1. Broken shading coil.	1. Replace shading coil.
	2. Magnet faces not mating.	2. Replace magnet assembly or realign.
	3. Dirt or rust on magnet faces.	3. Clean and realign.
	4. Low voltage.	4. Inspect system voltage and voltage dips during starting.
Failure to pick up and seal	1. Low voltage.	1. Inspect system voltage and correct.
	2. Coil open or shorted.	2. Replace.
	3. Wrong coil.	3. Check coil number and voltage rating.
	4. Mechanical obstruction.	4. With power off, check for free movement of contact and armature assembly. Repair.

Trouble	Possible Cause	Remedy
Failure to drop out	1. Gummy substance on pole.	1. Clean with solvent.
	2. Voltage not removed from coil.	2. Check coil circuit.
	3. Worn or rusted parts causing binding.	3. Replace or clean parts as necessary.
	4. Residual magnetism due to lack of air gap in magnet path.	4. Replace worn magnet parts or align if possible.
	5. Welded contacts.	5. Shorted circuit, grounded, overload.

8.271 TROUBLE SHOOTING GUIDE FOR ELECTRIC MOTORS

SYMPTOMS	CAUSE	RESULT*	REMEDY
1. Motor does not start. (Switch is on and not defective.)	a. Incorrectly connected.	a. Burnout	a. Connect correctly per diagram on motor.
	b. Incorrect power supply.	b. Burnout	b. Use only with correct rated power supply.
	c. Fuse out, loose or open connection.	c. Burnout	c. Correct open circuit condition.
	d. Rotating parts of motor may be jammed mechanically.	d. Burnout	d. Check and correct: 1. Bent shaft 2. Broken housing 3. Damaged bearing 4. Foreign material in motor.
	e. Driven machine may be jammed.	e. Burnout	e. Correct jammed condition.
	f. No power supply.	f. None	f. Check for voltage at motor and work back to power supply.
	g. Internal circuitry open.	g. Burnout	g. Correct open circuit condition.

---

* Many of these conditions should trip protective devices rather than burnout motors.

TROUBLE SHOOTING GUIDE FOR ELECTRIC MOTORS

Symptoms	Cause	Result	Remedy
2. Motor starts but does not come up to speed.	a. Same as 1-a, b, c above.	a. Burnout	a. Same as 1-a, b, c above.
	b. Overload.	b. Burnout	b. Reduce load to bring current to rated limit. Use proper fuses and overload protection.
	c. One or more phases out on a 3 phase motor.	c. Burnout	c. Look for open circuits.
3. Motor noisy electrically.	a. Same as 1-a, b, c above.	a. Burnout	a. Same as 1-a, b, c above.
4. Motor runs hot (exceeds rating)	a. Same as 1-a, b, c above.	a. Burnout	a. Same as 1-a, b, c above.
	b. Overload	b. Burnout	b. Reduce load.
	c. Impaired ventilation.	c. Burnout	c. Remove obstruction.
	d. Frequent start or stop.	d. Burnout	d. 1. Reduce number of starts or reversals. 2. Secure proper motor for this duty.
	e. Misalignment between rotor and stator laminations.	e. Burnout	e. Realign.
5. Noisy (Mechanically)	a. Misalignment of coupling or sprocket.	a. Bearing failure, broken shaft, stator burnout due to motor drag.	a. Correct misalignment.
	b. Mechanical unbalance of rotating parts.	b. Same as 5-a.	b. Find unbalanced part, then balance.
	c. Lack of or improper lubricant.	c. Bearing failure.	c. Use correct lubricant, replace parts as necessary.
	d. Foreign material in lubricant.	d. Same as 5-c.	d. Clean out and replace bearings.
	e. Overload.	e. Same as 5-c.	e. Remove overload condition. Replace damaged parts.
	f. Shock loading.	f. Same as 5-c.	f. Correct causes and replace damaged parts.
	g. Mounting acts as amplifier of normal noise.	g. Annoying.	g. Isolate motor from base.
	h. Rotor dragging due to worn bearings, shaft or bracket.	h. Burnout	h. Replace bearings, shaft or bracket as needed.

TROUBLE SHOOTING GUIDE FOR ELECTRIC MOTORS

Symptoms	Cause	Result	Remedy
6. Bearing Failure	a. Same as 5-a, b, c, d, e	a. Burnout, damaged shaft, damaged housing.	a. Replace bearings and follow 5-a,b,c,d,e.
	b. Entry of water or foreign material into bearing housing.	b. Same as 6-a.	b. Replace bearings and seals and shield against entry of foreign material (water, dust, etc.). Use proper motor.

Symptom	Caused By	Appearance
1. Shorted Motor Winding	a. Moisture, chemicals, foreign material in motor, damaged winding.	a. Black or burned coil with remainder of winding good.
2. All Windings Completely Burned	a. Overload. b. Stalled. c. Impaired ventilation. d. Frequent reversal or starting. e. Incorrect power.	a. Burned equally all around winding b. Burned equally all around winding c. Burned equally all around winding d. Burned equally all around winding e. Burned equally all around winding
3. Single phase condition.	a. Open circuit in one line. The most common causes are loose connection, one fuse out, loose contact in switch.	a. If 1800 RPM motor - four equally burned groups at 90° intervals. b. If 1200 RPM motor - six equally burned groups at 60° intervals. c. If 3600 RPM motor - two equally burned groups at 180°. NOTE: If Y connected each burned groups will consist of two adjacent phase groups. If delta connected each burned group will consist of one phase group.
4. Other	a. Improper connection. b. Ground	a. Irregularly burned groups or spot burns.

Many burnouts occur within a short period of time after motor is started up. This does not necessarily indicate that the motor was defective, but usually is due to one or more of the above mentioned causes. The most common of these are improper connections, open circuits in one line, incorrect power supply or overload.

8.272 Trouble-Remedy Chart for Induction Motors

A. Motor will not start.
Overload control tripped. Wait for overload to cool, then try to start again. If motor still does not start, check for the causes outlined below.

1. Open fuses: test fuses.
2. Low voltage: check name plate values against power supply characteristics. Also check voltage at motor terminals when starting motor under load to check for allowable voltage drop.
3. Wrong control connections: check connections with control wiring diagram.
4. Loose terminal-lead connection: turn power off and tighten connections.
5. Drive machine locked: disconnect motor from load. If motor starts satisfactorily, check driven machine.
6. Open circuit in stator or rotor winding: check for open circuits.
7. Short circuit in stator winding: check for short.
8. Winding grounded: test for grounded wiring.
9. Bearing stiff: free bearing or replace.
10. Overload: reduce load.

B. Motor noisy.

1. Three-phase motor running on single phase: stop motor, then try to start. It will not start on single phase. Check for open circuit in one of the lines.
2. Electrical load unbalanced: check current balance.
3. Shaft bumping (sleeve-bearing motor): check alignment and conditions of belt. On pedestal-mounted bearing check cord play and axial centering of rotor.

4. Vibration: driven machine may be unbalanced. Remove motor from load. If motor is still noisy, rebalance.

5. Air gap not uniform: center the rotor and if necessary replace bearings.

6. Noisy ball bearing: check lubrication. Replace bearings if noise is excessive and persistent.

7. Rotor rubbing on stator: center the rotor and replace bearings if necessary.

8. Motor loose on foundation: tighten hold-down bolts. Motor may possibly have to be realigned.

9. Coupling loose: insert feelers at four places in coupling joint before pulling up bolts to check alignment. Tighten coupling bolts securely.

C. Motor at higher than normal temperature or smoking. (Measure temperature with thermometer or thermister and compare with name plate value.)

1. Overload: measure motor loading with ammeter. Reduce load.

2. Electrical load unbalance: check for voltage unbalance or single-phasing.

3. Restricted ventilation: clean air passage and windings.

4. Incorrect voltage and frequency: check name plate values with power supply. Also check voltage at motor terminals with motor under full load.

5. Motor stalled by driven tight bearings: remove power from motor. Check machine for cause of stalling.

6. Stator winding shorted or grounded: test windings by standard method.

7. Rotor winding with loose connection: tighten, if possible, or replace with another rotor.

8. Belt too tight: remove excessive pressure on bearings.

9. Motor used for rapid reversing service: replace with motor designed for this service.

D. Bearings hot.

1. End shields loose or not replaced properly: make sure end shields fit squarely and are properly tightened.

2. Excessive belt tension or excessive gear side thrust: reduce belt tension or gear pressure and realign shafts. See that thrust is not being transferred to motor bearing.

3. Bent shaft: straighten shaft or send to motor repair shop.

E. Sleeve bearings.

1. Insufficient oil: add oil - if supply is very low, drain, flush, and refill.

2. Foreign material in oil or poor grade of oil: drain oil, flush, and relubricate using industrial lubricant recommended by a reliable oil manufacturer.

3. Oil rings rotating slowly or not rotating at all: oil too heavy; drain and replace. If oil ring has worn spot, replace with new ring.

4. Motor tilted too far: level motor or reduce tilt and realign if necessary.

5. Rings bent or otherwise damaged in reassembling: replace rings.

6. Rings out of slot (oil-ring retaining clip out of place): adjust or replace retaining clip.

7. Defective bearings or rough shaft: replace bearings. Resurface shaft.

F. Ball bearings.

1. Too much grease: remove relief plug and let motor run. If excess grease does not come out, flush and relubricate.

2. Wrong grade of grease: flush bearing and relubricate with correct amount of proper grease.

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3. Insufficient grease: remove relief plug and grease bearing.

4. Foreign material in grease: flush bearing, relubricate; make sure grease supply is clean (keep can covered when not in use).

8.28 Records

Records are a very important part of electrical maintenance. They must be accurate and complete. Whenever something is changed, repaired, or tested, it should be recorded on a material history card of some type. Pages 8-42 and 8-43 are examples of typical record sheets.

QUESTIONS

8.27A What is the key to effective trouble shooting?

8.27B What are some of the steps that should be taken when trouble shooting electrical equipment?

8.28A What kind of information should be recorded regarding electrical equipment?

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PUMP RECORD CARD

NAME ____ MAKE ____ MODEL ____

TYPE ____ SIZE ____ SERIAL # ____

ORDER NUMBER ____ SUPPLIER ____ DATE PURCHASED ____

DATE INSTALLED ____ APPLICATION ____ PLANT # ____

Name Plate Data and Info Pump   Stuffing Box Data   Motor Data

GPM   Diameter ____ Depth ____ Name ____ Serial # ____

TDH   Pack. Size ____ Type ____ H.P. ____ SPEED ____

RPM   Length ____ No. Rings ____ Ambient° ____

Gauge Press Disc ____ ____ Lantern Ring ____ Flushed ____ RPM ____ Frame ____

Gauge Press Suc ____ ____ Mech. Seal Name ____ Size ____ Volts ____ Amps ____

Shut off Press ____ ____   Type ____ Phase ____ Cycle ____

Suction Head ____ ____   Shaft Size ____ Key ____

Pump Materials

Rotation ____ ____ Casing ____ Bearing Front ____

Impeller Type ____ Shaft ____ Rear ____

Impeller Dia. ____ Wearing Rings Casing ____ Code ____ Type ____

Impeller Clear ____ Wearing Rings Impeller ____ Amps @ Max Speed ____

Coupl Type & Size ____ Shaft Sleeve ____ Amps @ Shut Off ____

Front Brg # ____ Slinger ____ Control Data Info

Rear Brg # ____ Shims ____ Starter ____

Lub Interval ____ Gaskets ____ MENA Size ____

Lubricant ____ "O" Rings ____ Cat. # ____

Wearing Rings ____ Brg. Seals Front ____ Heater Size ____

Shaft Sleeve Size ____ Rear ____ Rated @ ____

Pump Shaft Size ____ Casing Wear Ring Size ID ____ Control Voltage ____

Pump Keyway ____ OD ____ Variable Speed Type ____

____ Width ____ Speed Max ____

Other Related Information:

Impeller Wear Ring ID ____ Speed Min ____

OD ____

Width ____

MOTOR STARTERS

Number ____________

Title: ____________

Mfg.: ____________ Address ____________

Style: ____________ Class ____________ Size ____________

Type: ____________ ____________ ____________

O.L. HEATERS

Style ____________ Code ____________

AMPS ____________ ____________

____________ ____________

O.L. TRIP UNITS

Mfg: ____________ Style: ____________

Type: ____________ ____________

Amps. Range: ____________ ____________

CIRCUIT BREAKER

Mfg: ____________ Address ____________

Style: ____________ Frame: ____________ Volts ____________ Amps Setting ____________

Cat. No. ____________ ____________ ____________ ____________

MOTOR

Number ____________

TITLE ____________

MFG: ____________ Address ____________

HP: ____________ Volts: ____________ Ser. No. ____________ Duty: ____________

Phase: ____________ Amps: ____________ Frame: ____________ Temp: ____________

Cycles: ____________ RPM: ____________ Type ____________ Class: ____________

Code: ____________ S.F.: ____________ Model ____________ Spec.: ____________

SO# ____________ S# ____________ Style: ____________ CSA App: ____________

Form ____________ Spec. ____________ Shft. Brg. ____________ Rear Brg. ____________

50 Cycle Data ____________

Suitable for 208V Network: ____________

Additional data ____________

____

____

____

Connection Diagram

(6) (5) (4)   (6) (5) (4)
(7) (8) (9)   (7) (8) (9)
(1) (2) (3)   (1) (2) (3)

8.29 Additional Reading

1. "Basic Electricity" by Van Valkenburgh, Nooger & Neville, Inc., 15 Maiden Lane, New York, New York 10038.

    a. Volume 1. Price $3.40.
        - Where Electricity Comes From
        - Electricity in Action
        - Current Flow, Voltage, Resistance
        - Magnetism, DC Meters

    b. Volume 2. Price $3.75.
        - Direct Current
        - Ohm's and Kirchoff's Law
        - Electric Power

    c. Volume 3. Price $3.25.
        - Alternating Current
        - Resistance, Inductance, Capacitance in AC
        - Reactance
        - AC Meters

    d. Volume 4. Price $3.75.
        - Impedance
        - Alternating Current Circuits
        - Series and Parallel Resonance
        - Transformers

    e. Volume 5. Price $3.25.
        - DC Generators and Motors
        - Alternators and AC Motors
        - Power Control Devices

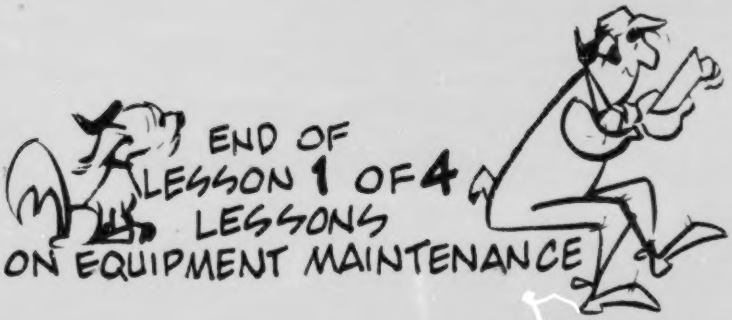
    f. Other Training Programs
        - Basic Electronics, 6 Volumes
        - Basic Industrial Electricity, 2 Volumes

2. "Maintenance" by Stan Walton, Chapter 11 in Operation of Wastewater Treatment Plants, Kenneth D. Kerri, California State University, Sacramento, 6000 Jay Street, Sacramento, CA 95819. Price for 17 chapter manual, $25.00.

3. "Electricity Principles and Practices" by Adams. Obtainable from Stationary Engineers, Local 39, 337 Valencia Street, San Francisco, CA 94103. Price $8.00.

4. "Electrical and Automation," Chapter XII in "Water Distribution Operator Training Manual," by I.E. Nichols and B.W. Jex, Technical Training Committee, California Section, American Water Works Association. Obtain from Mr. I.E. Nichols, San Diego Water Authority, 819 E. 5th, Escondido, CA 92025. Price $3.00 for members of California Section, $6.00 for others.

5. "Maintenance Engineering Handbook," Second Edition, by L.C. Morrow, Editor, McGraw-Hill Book Company, New York, New York. Price $39.50.



DISCUSSION AND REVIEW QUESTIONS

Chapter 8. Equipment Maintenance

(Lesson 1 of 4 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. Why should inexperienced, unqualified or unauthorized persons and even qualified and authorized persons be extremely careful around electrical panels, circuits, wiring and equipment?
2. What is the difference between direct current (D.C.) and alternating current (A.C.)?
3. What meters and testers are used to maintain, repair and trouble shoot electrical circuits and equipment? Discuss the use of each meter and tester.
4. What protective or safety devices are used to protect workers and equipment from being harmed by electricity?
5. Why must motor name plate data be recorded and filed?
6. How would you attempt to find the cause of a pump motor that won't start?

CHAPTER 8. EQUIPMENT MAINTENANCE

(Lesson 2 of 4 Lessons)

8.3 PUMPS

Pumps are used to move wastewater in collection systems when a gravity system is not feasible or too costly. In the collection system they are used in lift stations where it is necessary to lift the water from a low elevation to a higher elevation. Pumps also are used for cleaning collection systems in high velocity cleaners. They are used to dewater trenches or excavations while installing pipe lines or repairing them. Automobiles have oil pumps and water pumps, while backhoes have hydraulic pumps.

These pumps vary in type, construction, and use. There are centrifugal pumps, reciprocating pumps, turbine pumps, diaphragm pumps, gear pumps, screw pumps, and many others. Each type of pump is designed for a particular job or application.

Pump selection is based on several factors. Important considerations should include:

1. Type of material to be pumped:
    - A. Wastewater
    - B. Storm water
    - C. Sludge, grit
    - D. Mud, rocks, sand
    - E. Oil
    - F. Clear water.
2. Type of service required:
    - A. High pressure - low volume
    - B. High pressure - high volume
    - C. Low pressure - low volume
    - D. Low pressure - high volume.

990

3. Other factors should include:

   A. Reliability
   B. Required maintenance
   C. Parts availability
   D. Efficiencies
   E. Operating conditions.

Generally, centrifugal pumps are used for pumping wastewater; piston or diaphragm pumps for heavy solids; gear pumps and piston pumps for high pressures; and turbine or propeller pumps for mixing air or chemicals.

Pumps are so varied in their construction, operation, and maintenance that it is necessary to consult each manufacturers's instruction book for information regarding your particular pump. Each and every type and manufacturer of pumps cannot be discussed in this section, but several of the common types used in wastewater collection will be studied.

To better understand pumps and parts, the following section "Let's Build a Centrifugal Pump" is presented. The pump described is a clearwater pump, not a wastewater pump, but there are many similarities. The major difference is that wastewater pumps have open impellers (big openings) instead of closed impellers (small openings).

8.31 Let's Build a Pump

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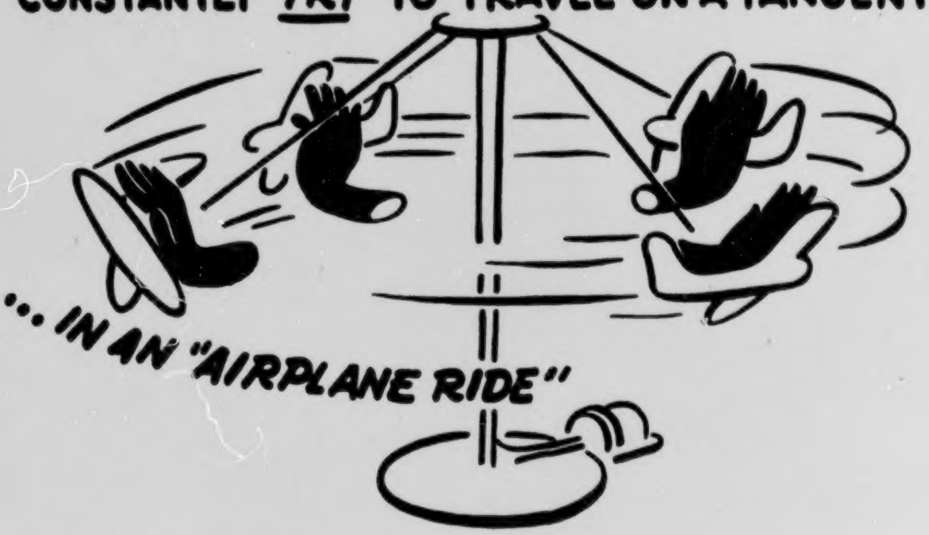
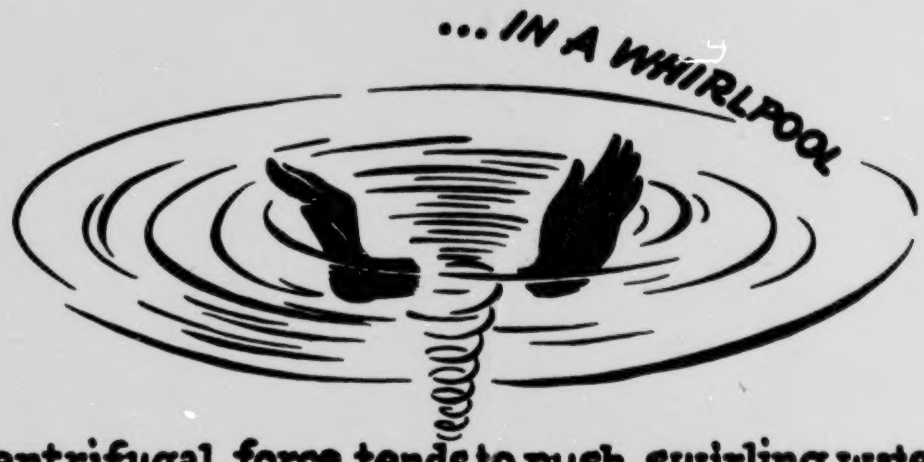
CENTRIFUGAL FORCE IN ACTION--

ALL MOVING BODIES TEND TO TRAVEL IN A STRAIGHT LINE. WHEN FORCED TO TRAVEL IN A CURVE, THEY CONSTANTLY TRY TO TRAVEL ON A TANGENT...



Centrifugal force pushes dummy planes swung in a circle *away* from center of rotation.



Centrifugal force tends to push swirling water *outward*... forming vortex in center.

Let's Build a Pump!

A student of medicine spends long years learning exactly how the human body is built before he ever attempts to prescribe for its care. Knowledge of *pump* anatomy is equally basic in caring for centrifugal pumps!

But whereas the medical student must take a body apart to learn its secrets, it will be far more instructive to us if we put a pump *together* (on paper, of course). Then we can start at the beginning—adding each new part as we need it in logical sequence.

As we see *what* each part does, *how* it does it . . . we'll see how it must be *cared for!*

Another analogy between medicine and maintenance: there are various types of human bodies, but if you know basic anatomy, you understand them all. The same is true of centrifugal pumps. In building one basic type, we'll learn about *all* types.

Part of this will be elementary to some maintenance men . . . but they will find it a valuable "refresher" course, and, after all, maintenance just can't be too good.

So with a side glance at the centrifugal principle on the page at the left, let's get on with building our pump . . .

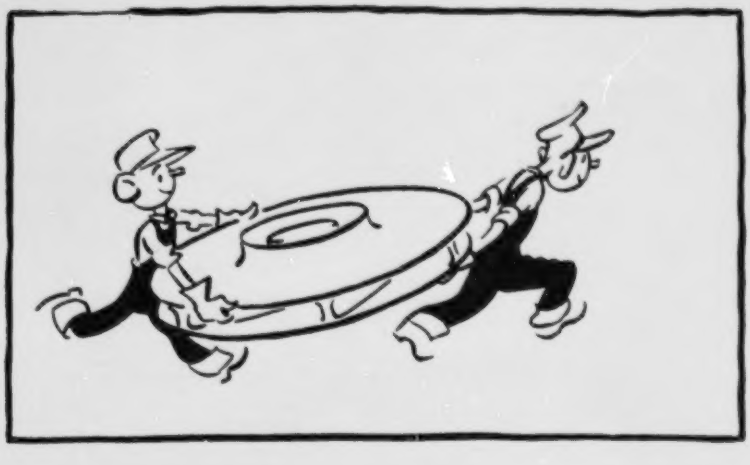
First we require a device to spin liquid at high speed...

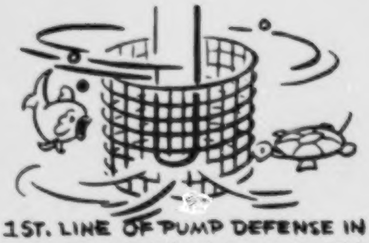
THAT paddle-wheel device is called the "impeller" . . . and it's the heart of our pump.

Note that the blades curve out from its hub. As the impeller spins, liquid between the blades is impelled outward by centrifugal force.

Note, too, that our impeller is open at the center — the "eye". As liquid in the impeller moves outward, it will suck more liquid in behind it through this eye . . . *provided it's not clogged!*

That brings up Maintenance Rule No. 1: if there's any danger that foreign matter (sticks, refuse, etc.) may be sucked into the pump — clogging or wearing the impeller unduly — provide the intake end of the suction piping with a suitable screen.





1ST. LINE OF PUMP DEFENSE IN WATER CARRYING STICKS, ETC!

Now we need a shaft to support and turn the impeller...

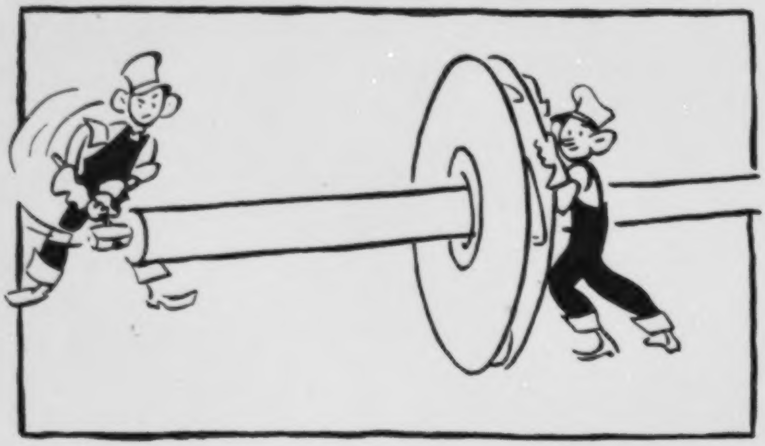
OUR shaft looks heavy — and it *is*. It must maintain the impeller in precisely the right place.

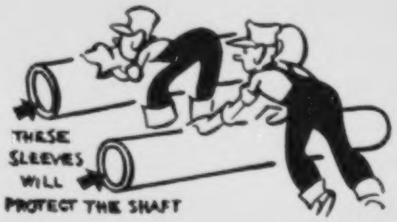
But that ruggedness does *not* protect the shaft from the corrosive or abrasive effects of the liquid pumped . . . so we must protect it with sleeves slid on from either end.

What these sleeves — and the impeller, too — are made of depends on the nature of the liquid we're to pump. Generally they're bronze, but various other alloys, ceramics, glass, or even rubber-coating are sometimes required.

Maintenance Rule No. 2: never pump a liquid for which the pump was not designed.

Whenever a change in pump application is contemplated and there's any doubt as to the pump's ability to resist the different liquid, check with your pump manufacturer!



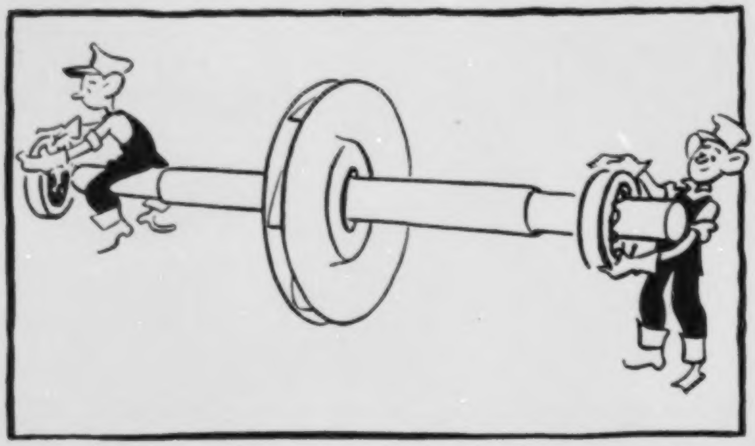

THESE SLEEVES WILL PROTECT THE SHAFT

We mount the shaft on sleeve, ball or roller bearings...

AS we'll see later, clearances between moving parts of our pump are *quite small*.

If bearings supporting the turning shaft and impeller are allowed to wear excessively and lower the turning units within a pump's closely-fitted mechanism, the life and efficiency of that pump will be seriously threatened.

Maintenance Rule No. 3: keep the right amount of the right lubricant in bearings at all times. Follow your pump manufacturer's lubrication instructions to the letter.



Main points to keep in mind are . . .

1. Although too much oil won't harm sleeve bearings, too much grease in anti-friction type bearings (ball or roller) will *promote* friction and heat. Main job of grease in anti-friction bearings is to protect steel elements against corrosion, not friction.

2. Operating conditions vary so widely that no one rule as to frequency of changing lubricant will fit all pumps. So play safe: if anything, change lubricant *before* it's too worn or too dirty.

Lubricants are cheaper than new pumps — and easier to get.

To connect with the motor, we add a coupling flange...

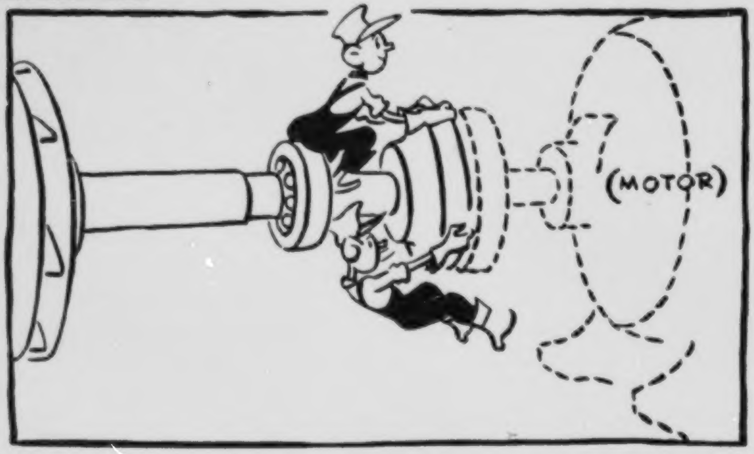
SOME pumps are built with pump and motor on one shaft, of course, and offer no alignment problem.

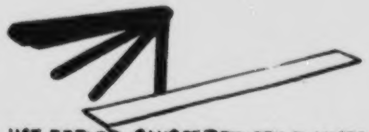
But our pump is to be driven by a separate motor . . . and we attach a flange to one end of the shaft through which bolts will connect with the motor flange.

Maintenance Rule No. 4: see that pump and motor flanges are parallel vertically and axially . . . and that they're *kept* that way!

If shafts are eccentric or meet at an angle, every revolution throws tremendous extra load on bearings of both pump and motor. Flexible couplings will *not* correct this condition if excessive.

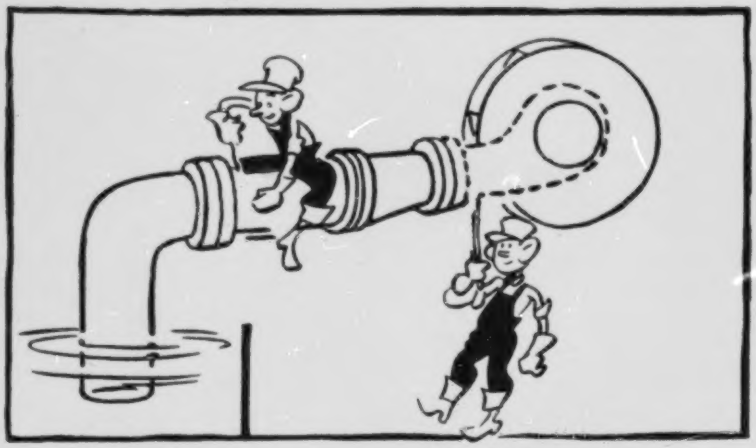
Checking alignment should be regular procedure in pump maintenance. Foundations can settle unevenly, piping can change pump position, bolts can loosen. Misalignment is a *major* cause of pump and coupling wear.





USE FEELER GAUGES BETWEEN FLANGES
A STRAIGHT-EDGE ACROSS TOPS AND SIDES.

Now we need a "straw" through which liquid can be sucked...

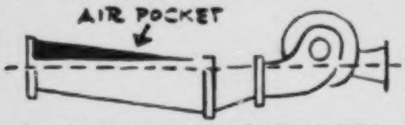


NOTICE two things about the suction piping: 1) the horizontal piping slopes *upward* toward the pump; 2) any reducer which connects between the pipe and pump intake nozzle should be horizontal at the top — (*eccentric,* not concentric).

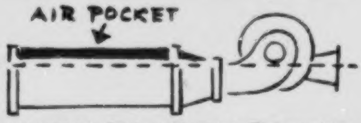
This up-sloping prevents air pocketing in the top of the pipe . . . which air might be drawn into the pump and cause loss of suction.

Maintenance Rule No. 5: any down-sloping toward the pump in suction piping (as exaggerated in the diagrams below) should be corrected.

This rule is *very* important. Loss of suction greatly endangers a pump . . . as we'll see shortly.



ALLOWED BY DOWN-SLOPING PIPE



ALLOWED BY TAPERED REDUCER

A flexible coupling will not compensate for misalignment.

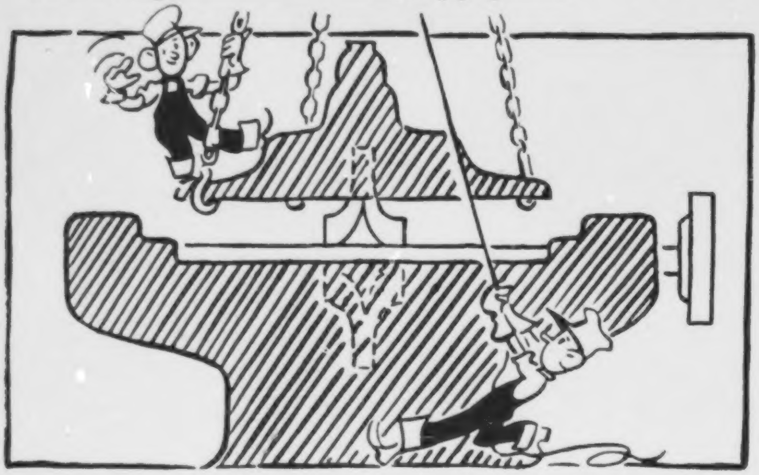
We contain and direct the spinning liquid with a casing...

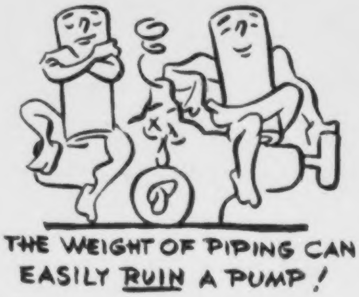
WE got a little ahead of our story on the page before . . . because we didn't yet have the casing to which the suction piping bolts. And the manner in which it is attached is of great importance.

Maintenance Rule No. 6: see that piping puts absolutely no strain on the pump casing.

When the original installation is made, all piping should be in place and self-supporting before connection. Openings should meet with no force. Otherwise the casing is apt to be cracked . . . or sprung enough to allow closely-fitted pump parts to rub.

It's good practice to check the piping supports regularly to see that loosening, or settling of the building, hasn't put strains on the casing.




THE WEIGHT OF PIPING CAN EASILY RUIN A PUMP!

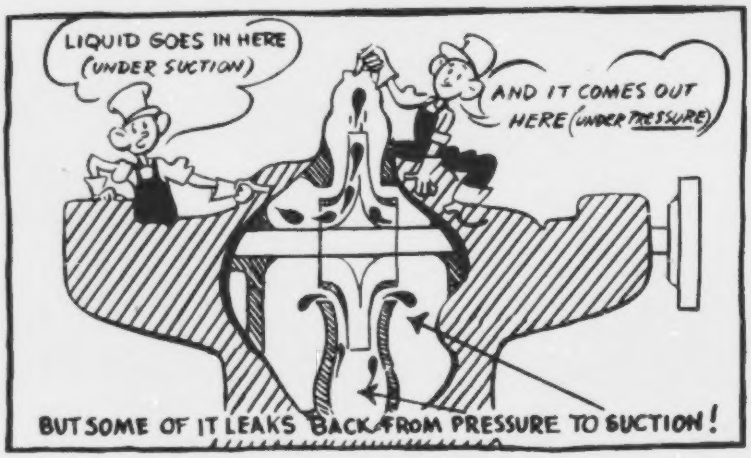
Now our pump is almost complete, but it would leak like a sieve...

WE'RE far enough along now to trace the flow of water through our pump. It's not easy to show suction piping in the cross-section view above, so imagine it stretching from your eye to the lower center of the pump.

Our pump happens to be a "double suction" pump, which means that water flow is divided inside the pump casing . . . reaching the eye of the impeller from either side.

As water is sucked into the spinning impeller, centrifugal force causes it to flow outward . . . building up high pressure at the outside of the pump (which will force water *out*) and creating low pressure at the center of the pump (which will suck water *in*.) This situation is diagrammed in the upper half of the pump, above.

So far so good . . . except that water tends to be sucked back from pressure to suction through the space between impeller and casing — as diagrammed in the lower half of the pump, above — and our next step must be to plug this leak, if our pump is to be very efficient!


LIQUID GOES IN HERE (UNDER SUCTION)
AND IT COMES OUT HERE (UNDER PRESSURE)
BUT SOME OF IT LEAKS BACK FROM PRESSURE TO SUCTION!

Never allow a pump to run dry.

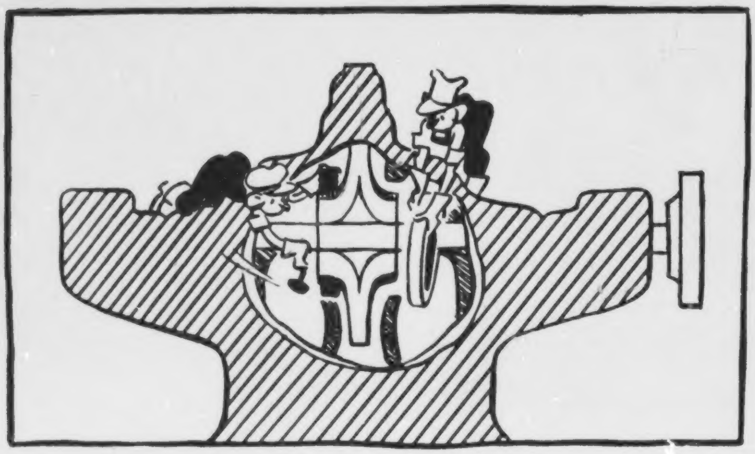
So we add wearing rings to plug internal liquid leakage...

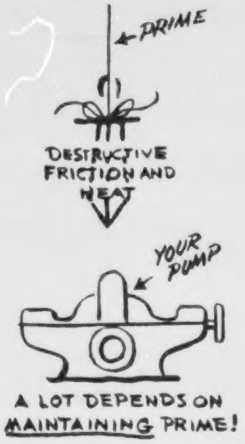
YOU might ask why we didn't build our parts closer fitting in the first place — instead of narrowing the gap between them by inserting wearing rings.

The answer is that those rings are removable and *replaceable* . . . when wear enlarges the tiny gap between them and the impeller. (Sometimes rings are attached to impeller rather than casing — or rings are attached to *both* so they face each other.)

Maintenance Rule No. 7: never allow a pump to run dry (either through lack of proper priming when starting or through loss of suction when operating). Water is a *lubricant* between rings and impeller.

Maintenance Rule No. 8: examine wearing rings at regular intervals. When seriously worn, their replacement will greatly improve pump efficiency.




PRIME
DESTRUCTIVE FRICTION AND HEAT
YOUR PUMP
A LOT DEPENDS ON MAINTAINING PRIME!

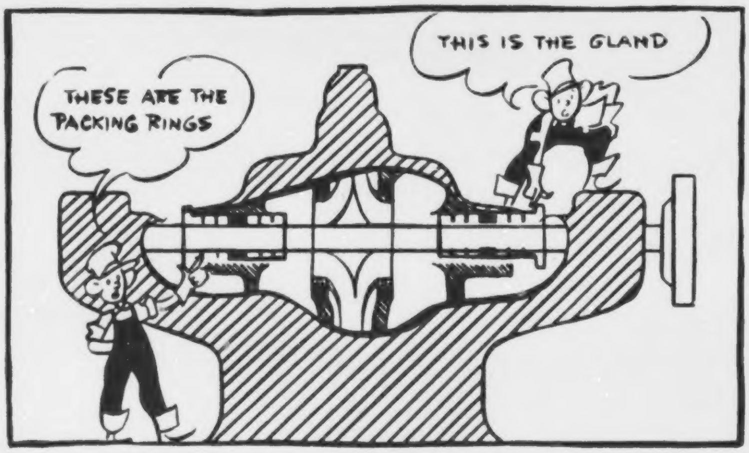
To keep air from being sucked in, we use stuffing boxes...

WE have two good reasons for wanting to keep air out of our pump: 1) we want to pump water, not air; 2) air leakage is apt to cause our pump to lose suction.

Each stuffing box we use consists of a casing, rings of packing and a gland at the outside end.

Maintenance Rule No. 9: packing should be replaced periodically — depending on conditions — using the packing recommended by your pump manufacturer. Forcing in a ring or two of new packing instead of replacing worn packing is *bad practice*. It's apt to displace the seal cage (see next page).

Put each ring of packing in separately, seating it firmly before adding the next. Stagger adjacent rings so the points where their ends meet do not coincide.


THESE ARE THE PACKING RINGS
THIS IS THE GLAND

Maintenance Rule No. 10: never tighten a gland more than necessary . . . as excessive pressure will wear shaft sleeves unduly.

Maintenance Rule No. 11: if shaft sleeves are badly scored, replace them immediately . . . or packing life will be entirely too short.

A pump that often loses its prime is soon past its prime.

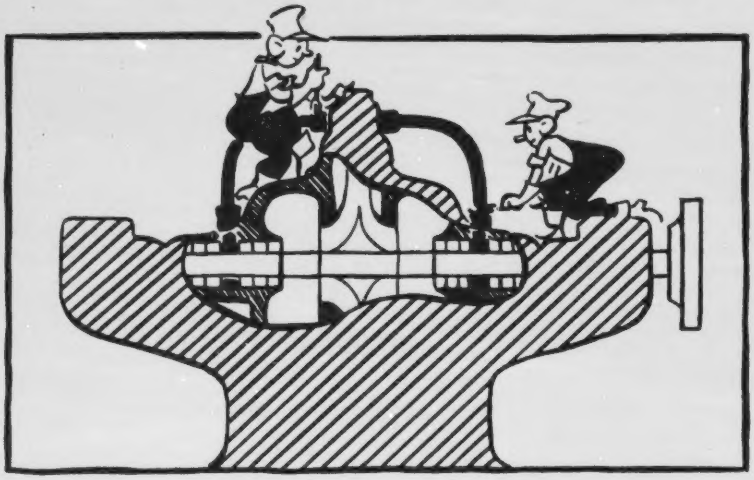
To make packing more air-tight, we add water seal piping...

IN the center of each stuffing box is a "seal cage". By connecting it with piping to a point near the impeller rim, we bring liquid *under pressure* to the stuffing box.

This liquid acts both to block out air intake and to lubricate the packing. It makes both packing and shaft sleeves wear longer . . . *providing it's clean liquid!*

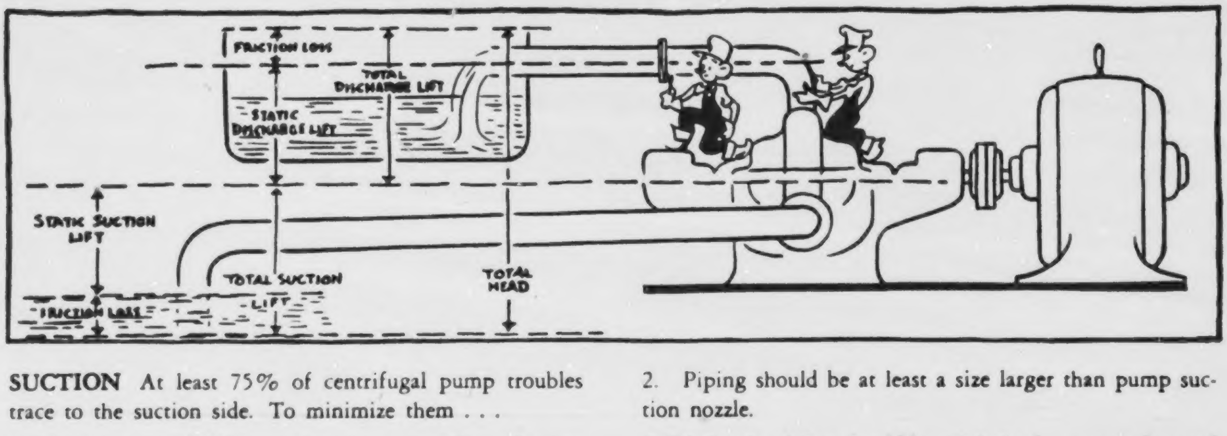
Maintenance Rule No. 12: if the liquid being pumped contains grit, a separate source of sealing liquid should be obtained (e.g. it may be possible to direct some of the pumped liquid into a container and settle the grit out).

To control liquid flow, draw up the gland just tight enough so a *thin* stream flows from the stuffing box during pump operation.



WATER IS A LUBRICANT!

Discharge piping completes the pump installation — and now we can analyze the various forces we're dealing with...



SUCTION At least 75% of centrifugal pump troubles trace to the suction side. To minimize them . . .

1. Total suction lift (distance between center line of pump and liquid level when pumping, plus friction losses) generally should not exceed 15 feet.

2. Piping should be at least a size larger than pump suction nozzle.

3. Friction in piping should be minimized . . . use as few and as easy bends as possible . . . avoid scaled or corroded pipe

A lot depends on packing — watch it!

DISCHARGE lift, plus suction lift, plus friction in the piping from the point where liquid enters the suction piping to the end of the discharge piping equals total head.

Pumps should be operated near their rated heads.

Otherwise, pump is apt to operate under unsatisfactory and unstable conditions which reduce efficiency and operating life of the unit.

Note the description of "cavitation" below — and directions for figuring the head your pumps are working against,

PUMP CAPACITY generally is measured in gallons per minute. A new pump is guaranteed to deliver its rating in capacity and head.

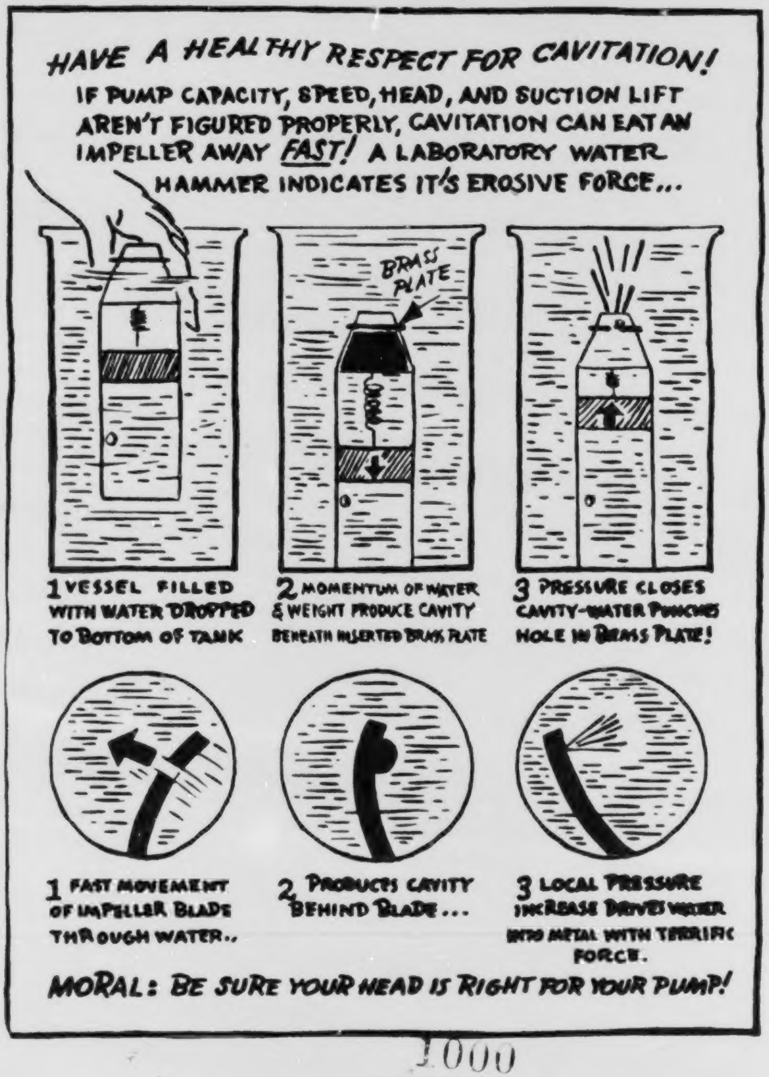
But whether a pump *retains* its actual capacity depends to a great extent on its maintenance.

Wearing rings must be replaced when necessary — to keep internal leakage losses down.

Friction must be minimized in bearings and stuffing boxes by proper lubrication . . . and misalignment must not be allowed to force scraping between closely-fitted pump parts.

POWER of the driving motor, like capacity of the pump, will not remain at a constant level without proper maintenance. (If you use electric motors, by all means send for Allis-Chalmers free "Guide to Care of Electric Motors"!)

Starting load on motors can be reduced by throttling or closing the pump discharge valve (*never* the suction valve!) . . . but the pump must not be operated for long with the discharge valve closed. Power then is converted into friction — overheating the water with serious consequences.


HAVE A HEALTHY RESPECT FOR CAVITATION!
IF PUMP CAPACITY, SPEED, HEAD, AND SUCTION LIFT AREN'T FIGURED PROPERLY, CAVITATION CAN EAT AN IMPELLER AWAY FAST! A LABORATORY WATER HAMMER INDICATES IT'S EROSIVE FORCE...
BRASS PLATE
1 VESSEL FILLED WITH WATER DROPPED TO BOTTOM OF TANK
2 MOMENTUM OF WATER & WEIGHT PRODUCE CAVITY BENEATH INSERTED BRASS PLATE
3 PRESSURE CLOSES CAVITY-WATER PUNCHES HOLE IN BRASS PLATE!
1 FAST MOVEMENT OF IMPELLER BLADE THROUGH WATER..
2 PRODUCES CAVITY BEHIND BLADE...
3 LOCAL PRESSURE INCREASE DRIVES WATER INTO METAL WITH TERRIFIC FORCE.
MORAL: BE SURE YOUR HEAD IS RIGHT FOR YOUR PUMP!

QUESTIONS

8.31A What are some uses of pumps?

8.31B Why is it important to know how a pump is built?

8.31C When should pump lubricants be changed?

8.31D How can you determine if a pump is in proper alignment?

8.31E Why must horizontal suction lift piping always slope upward towards the pump?

8.31F How can piping be prevented from putting a strain on the pump casing?

8.31G Why should a pump never be allowed to run dry?

8.32 Pump Types and Parts

After understanding the pump construction, you notice that there are several components and parts. Most of these are similar in construction, material, and location in all manufacturers' pumps. To help you find the location of the different parts and troubleshoot pumps that don't perform properly, the following figures show cut-away views of different types of pumps, and the location and name of the pump parts.

1. Figure 8.14 Horizontal Non-Clog Wastewater Pump with Open Impeller
2. Figure 8.15 Vertical Ball-Bearing Type Wastewater Pump
3. Figure 8.16 Propeller Pump
4. Figure 8.17 Incline Screw Pump
5. Figure 8.18 Pneumatic Ejector
6. Figure 8.19 Piston Pump on High Velocity Cleaner
7. Figure 8.20 Submersible Pump

Every manufacturer has an operation, maintenance, and repair manual for their particular pump. These manuals contain installation instruction, start-up procedures, operation information, maintenance program, lubrication schedules, repair procedures, parts list, and other valuable information. These should be in the file for each pump in your system. If you need a brochure for a particular pump, ask your salesman, supplier, or write to the manufacturer. Very seldom is there a charge for these manuals, but, if so, it is minimal and well worth the investment.

8.321 Centrifugal Pumps

Figures 8.14 through 8.16 illustrate different types of centrifugal pumps.

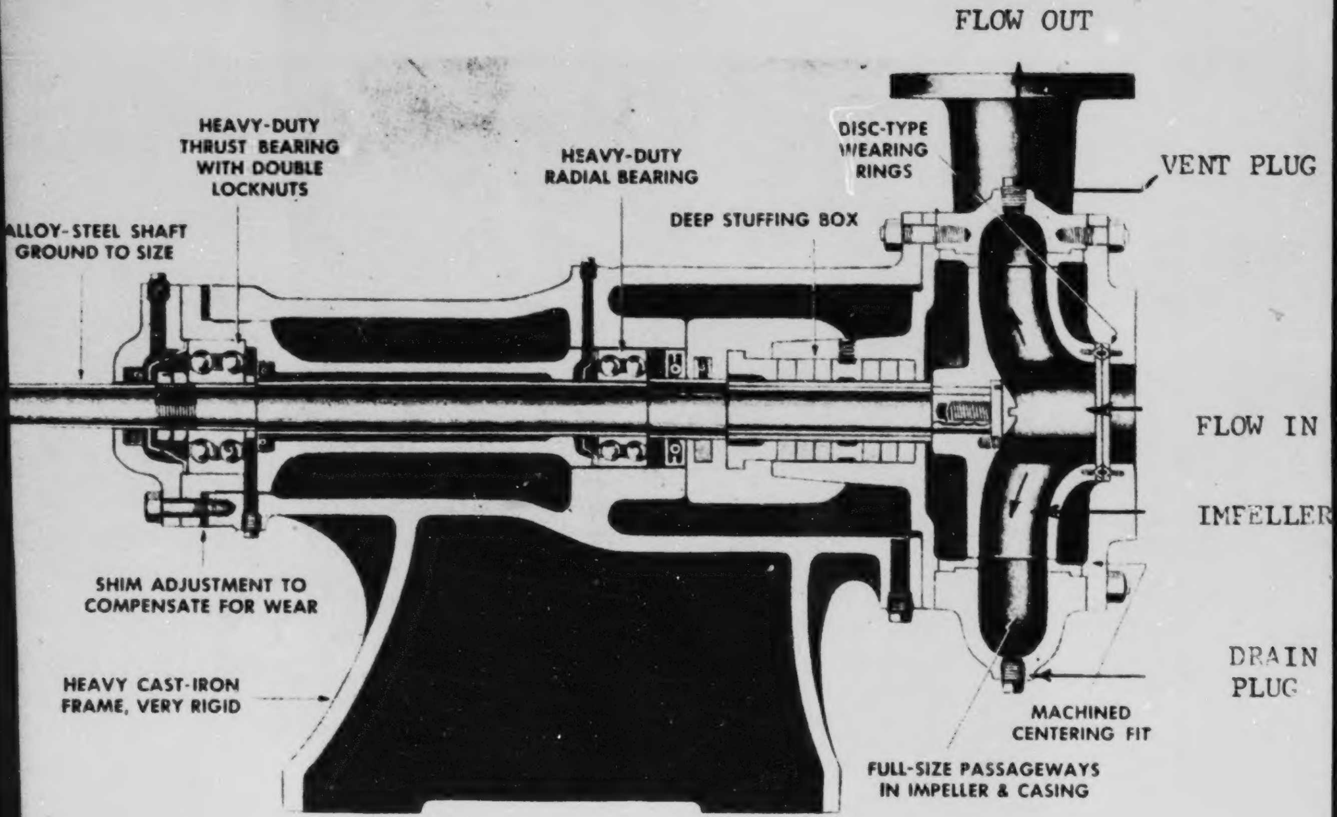

FLOW OUT
HEAVY-DUTY THRUST BEARING WITH DOUBLE LOCKNUTS
HEAVY-DUTY RADIAL BEARING
DISC-TYPE WEARING RINGS
VENT PLUG
ALLOY-STEEL SHAFT GROUND TO SIZE
DEEP STUFFING BOX
FLOW IN
IMPELLER
SHIM ADJUSTMENT TO COMPENSATE FOR WEAR
DRAIN PLUG
HEAVY CAST-IRON FRAME, VERY RIGID
MACHINED CENTERING FIT
FULL-SIZE PASSAGEWAYS IN IMPELLER & CASING

Fig. 8.14. Horizontal non-clog wastewater pump with open impeller

(Source: War Department Technical Manual TM5-666)

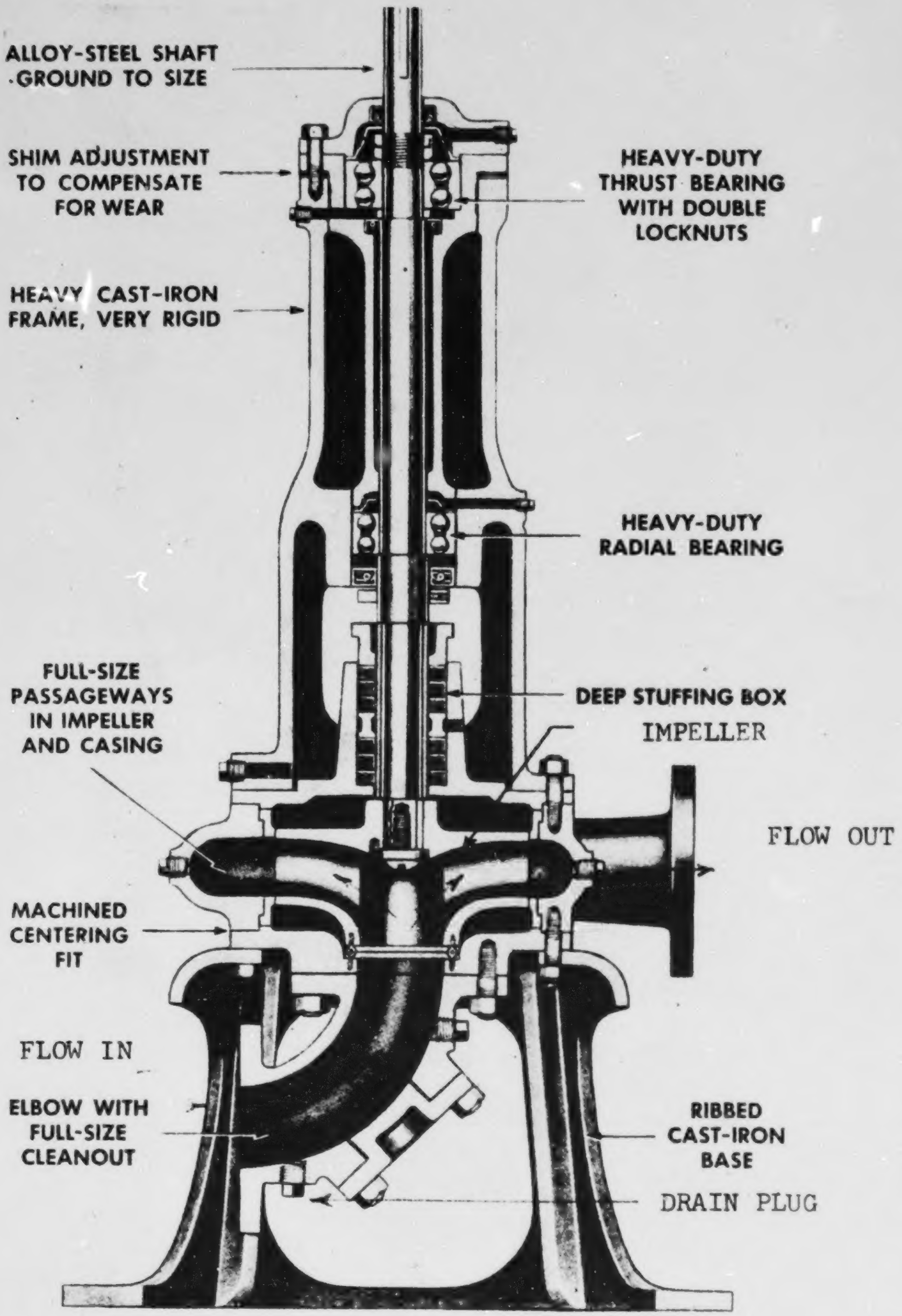

ALLOY-STEEL SHAFT GROUND TO SIZE
SHIM ADJUSTMENT TO COMPENSATE FOR WEAR
HEAVY-DUTY THRUST BEARING WITH DOUBLE LOCKNUTS
HEAVY CAST-IRON FRAME, VERY RIGID
HEAVY-DUTY RADIAL BEARING
FULL-SIZE PASSAGEWAYS IN IMPELLER AND CASING
DEEP STUFFING BOX
IMPELLER
FLOW OUT
MACHINED CENTERING FIT
FLOW IN
ELBOW WITH FULL-SIZE CLEANOUT
RIBBED CAST-IRON BASE
DRAIN PLUG

Fig. 8.15. Vertical ball-bearing type wastewater pump

(Source: War Department Technical Manual TM5-666)

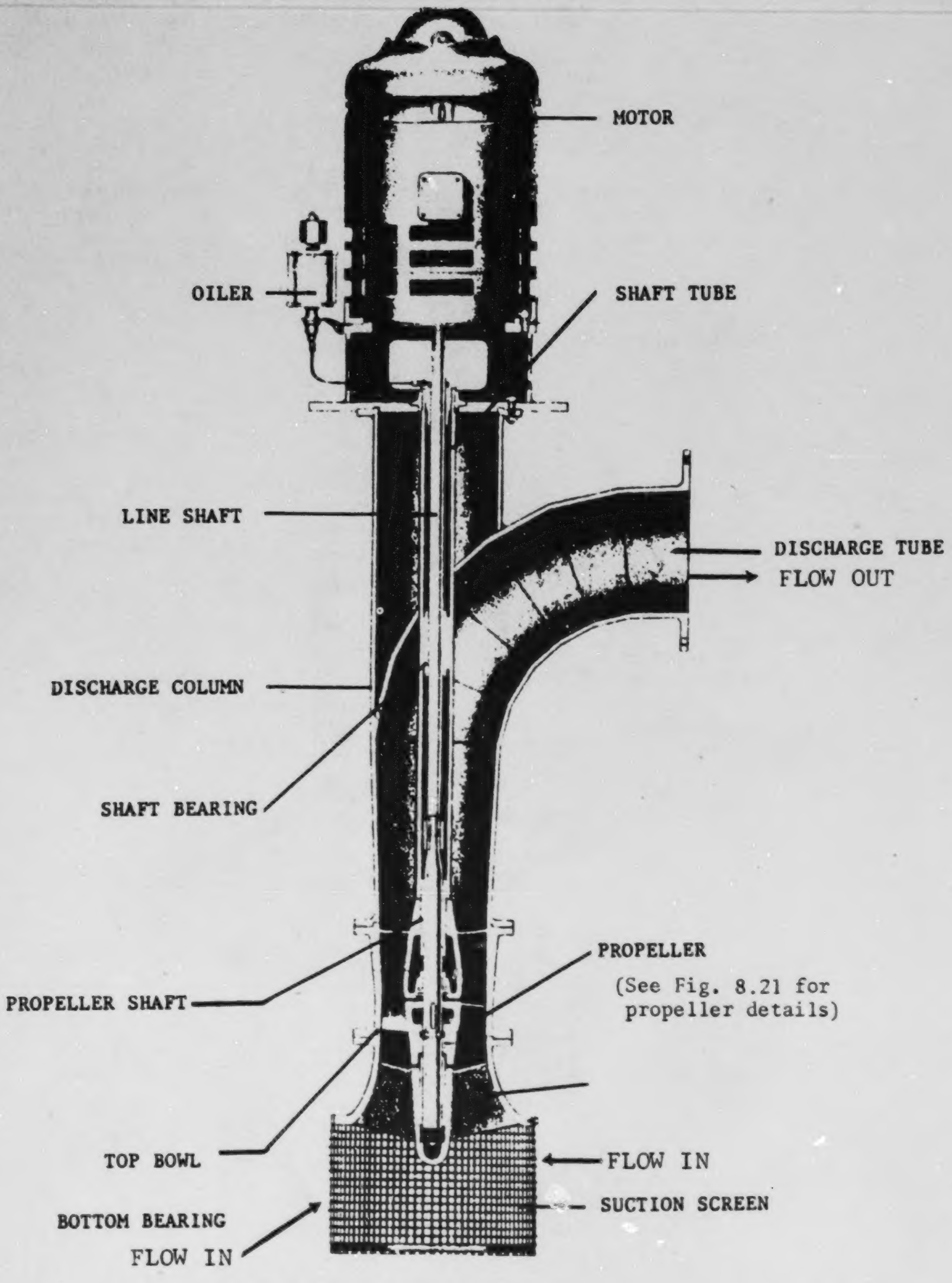

MOTOR
OILER
SHAFT TUBE
LINE SHAFT
DISCHARGE TUBE
FLOW OUT
DISCHARGE COLUMN
SHAFT BEARING
PROPELLER
(See Fig. 8.21 for propeller details)
PROPELLER SHAFT
TOP BOWL
FLOW IN
SUCTION SCREEN
BOTTOM BEARING
FLOW IN

Fig. 8.16. Propeller pump

(Source: Unknown)

1005

8.322 Screw Pumps (Fig. 8.17)

Screw pumps are another type of pump used to lift wastewater to a higher elevation. This pump consists of a screw operating at a constant speed within a housing or trough. The screw has a pitch and is set at a specific angle. When revolving, it conveys the wastewater up the trough to a discharge point. The discharge is usually a free discharge. The screw is constructed of a steel tube with flights welded around it and looks very similar to a screw conveyor. The trough can be either steel or concrete depending upon size of screw and preference.

The screw is supported by two bearings, one at the top and one on the bottom. The upper bearing is generally a ball or roller bearing, and the lower bearing is a sleeve bearing designed for underwater service. The bearings must be lubricated according to manufacturer's recommendations. If either bearing fails, it must be replaced immediately before the screw rubs on the trough and causes damage.

Screw pumps are usually driven by helical (spiral) gear speed reducers powered by electric motors. The speed reducers must be filled with a proper oil recommended by the equipment manufacturer. The oil level should be checked according to manufacturer's recommendations, such as a weekly measurement and changed at least every six months.

Screw pumps should be inspected daily for bent flights, unusual noises, and general operating condition.

1006

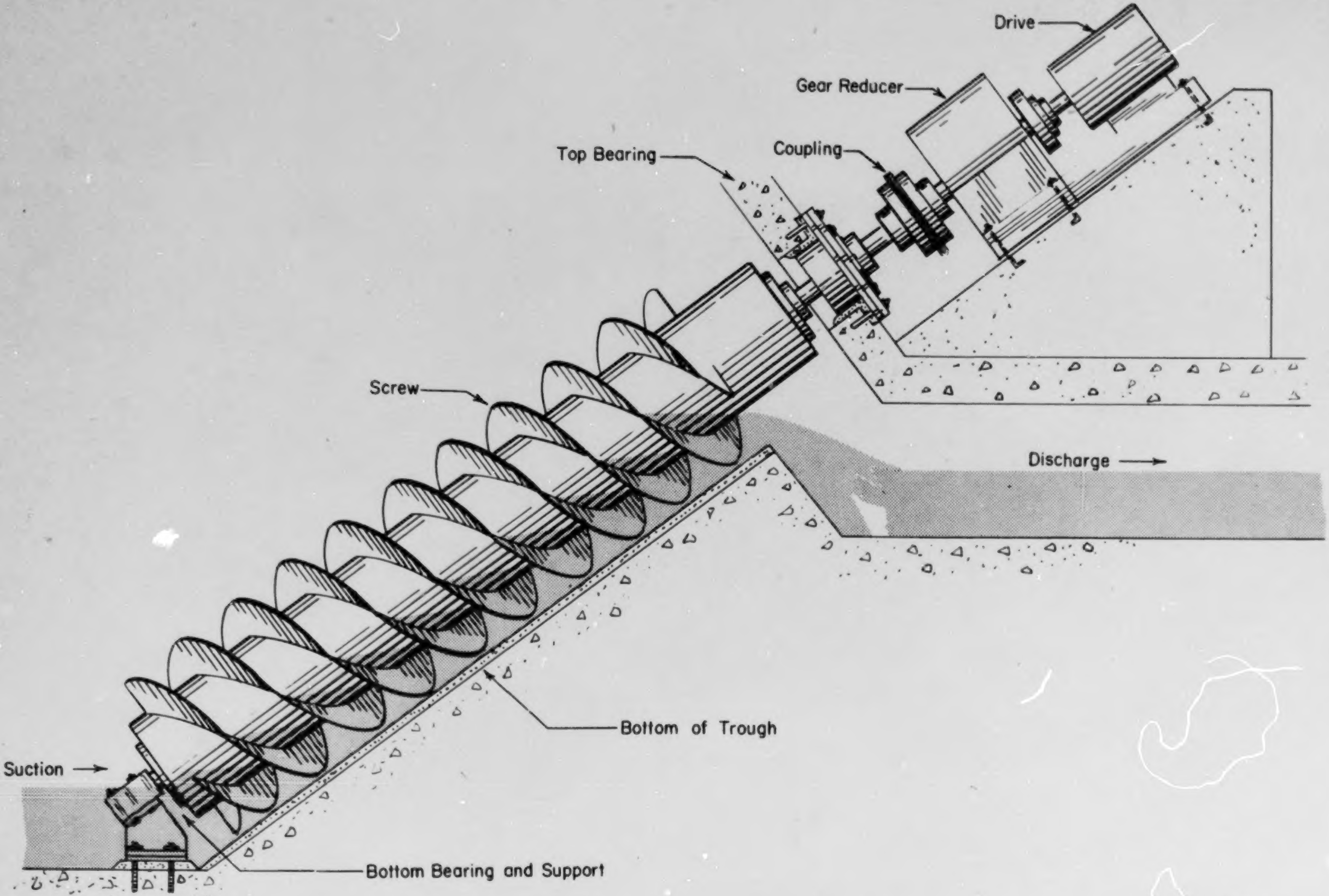

Drive
Gear Reducer
Coupling
Top Bearing
Screw
Discharge
Bottom of Trough
Suction
Bottom Bearing and Support

Fig. 8.17. Incline screw pump.
(Courtesy of FMC Corporation, Environmental Equipment Division)

Screw pumps have fairly high maximum operating efficiencies, ranging as high as 75 to 80 percent. A unique characteristic is that they generally do not lose more than 10 to 15 percent of the maximum efficiency throughout the entire 85 to 90 percent of their upper capacity pumping range. They are a constant speed pump which has the capability to pump from no-flow to maximum flow directly dependent upon the rate of incoming flow to the lower end of the screw. Greater pumping rates are the result of increased submergence which will occur when higher flows are present, and lesser pumping rates are achieved by just the opposite conditions. Screw pumps are capable of handling large solids and rags without plugging. Wherever these pumps are installed, proper hand rails, guards, and barriers should be installed to protect workers and equipment from entering the pumping area. Special precautions must be taken to avoid problems caused by splashing on trough sidewalls and steps. Good cleanup procedures are needed to avoid a slippery and odorous mess.

An anti-reverse rotational back stop is usually incorporated in the gear reducer to prevent the liquid trapped in the screw from driving it in the reverse direction when it runs back down the trough at the time of power cut-off.

WARNING

Before working on any part of this pump, be sure the electrical panel is tagged off and the motor main breaker is locked out.

8.323 Pneumatic Ejectors (Fig. 8.18)

Pneumatic ejectors are used when it is necessary to handle limited flows with relatively large solids. Centrifugal pumps are highly efficient for pumping large flows; however, when scaled down for lower flows, they tend to plug easily. There is a restriction of flow in a centrifugal pump because the impeller opening is too small to pass unstrained solids. Pneumatic ejectors, on the other hand, are capable of passing solids up to the size of the inlet and discharge valves, and there is nothing on the inside of the ejector-receiver to restrict the flow.

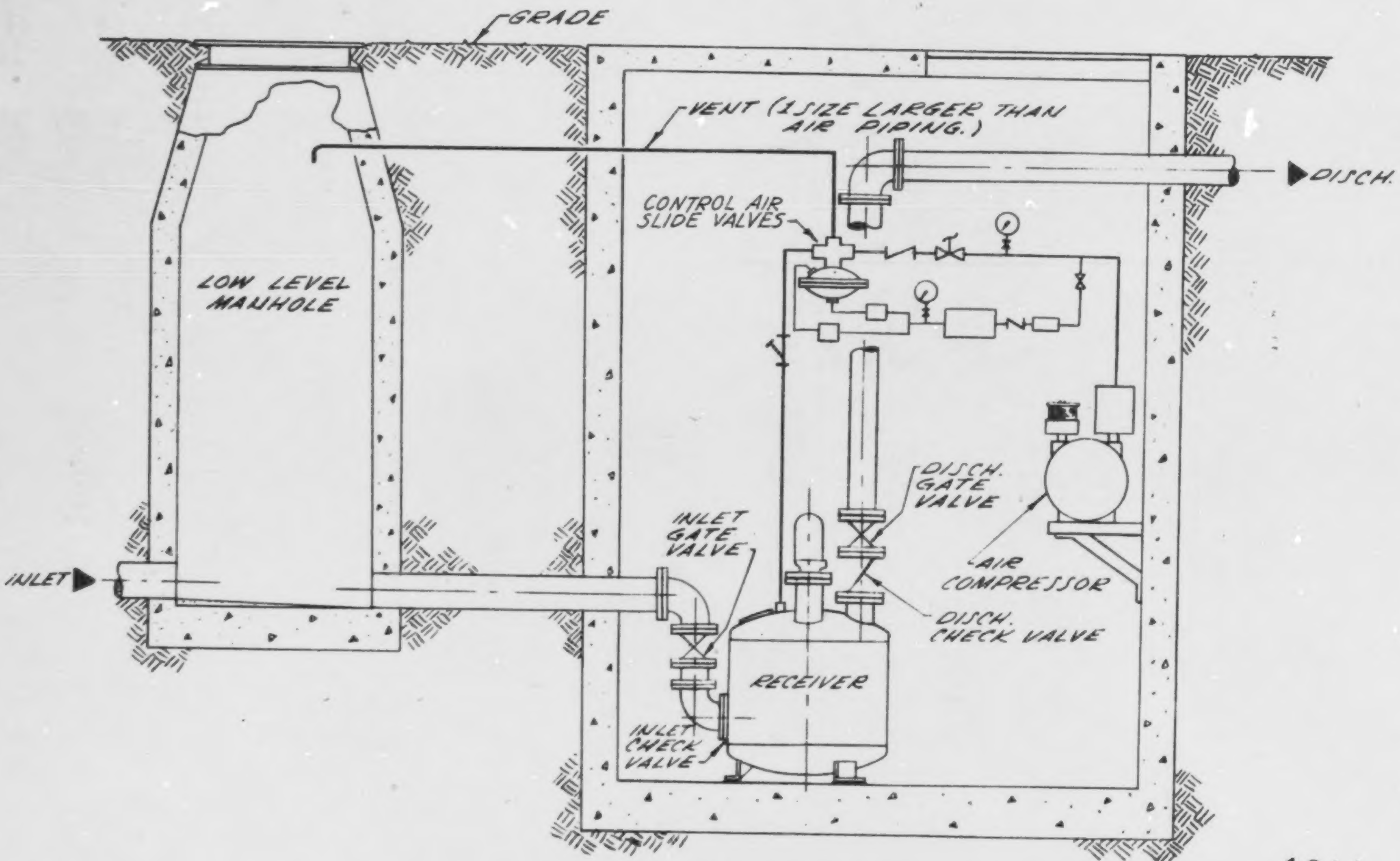

GRADE
VENT (1 SIZE LARGER THAN AIR PIPING.)
DISCH.
CONTROL AIR SLIDE VALVES
LOW LEVEL MANHOLE
DISCH. GATE VALVE
INLET GATE VALVE
AIR COMPRESSOR
INLET
DISCH. CHECK VALVE
RECEIVER
INLET CHECK VALVE

Fig. 8.18. Pneumatic ejector system.
(Courtesy of James Equipment and Manufacturing Company)

The pneumatic ejector is a clean, reliable device for pumping wastewater. The ejector consists simply of two check valves, an air valve, and a receiver or tank. Wastewater flows into the receiver by gravity. When the ejector is filled, a control admits compressed air to force out the wastewater in the receiver.

Pneumatic ejector systems fall into four categories:

1. Tankless System. A compressor with no intermediate air tank is supplied with each ejector, and starts each time the unit is filled.

2. Package System. This is an ejector with the compressor mounted above the receiver and without an air storage tank. The controls and compressor are prewired and mounted at the factory.

3. Stored Air System. In this system, an air tank is used between the compressor and the ejector. This arrangement has the advantage that more than one compressor can be used for standby.

4. Plant Air System. If an ample supply of air is available from a wastewater treatment plant, this air can be used rather than installing another air compressor.

The pneumatic ejector has a built-in level control device that produces an intermittent discharge. This control is either electrically or pneumatically operated, depending on the job requirements.

Maintenance of pneumatic ejectors is not as complicated as maintenance of most pumps; however, maintenance must be performed when scheduled. Clean the interior of the pots to remove grease. Inspect valves, floats and/or electrical controls for proper operation. If a failure occurs and wastewater enters the air lines or air control valves, dismantle and clean. The motor and air compressor require regular preventive maintenance and overhaul.

OPERATION PROBLEM CHECK LIST

Ejector Will Not Discharge

Cause:	Procedure and Cure:
1. Ejector not filling	Inlet gate valve and check valve closed or plugged. Open and/or clean.
2. Insufficient air pressure or volume	One psi of pressure for each 2 feet of discharge head is the minimum air pressure needed for discharge. The amount of air determines the discharge time. Remember that the inlet check valve is closed during discharge.
3. Pilot valve not functioning	A. Counterweight must be in the down position to discharge ejector. The counterweight is a weight on the end of a lever on the check valve that helps the check valve operate properly. B. Accumulation of grease and foreign matter on upper bell preventing proper travel to shift the pilot valve. Check top of bell and clean as necessary through access opening in wastewater receiver. C. Check air supply.
4. Strainer and air line to receiver plugged	Remove and clean.
5. Discharge gate or check valve closed or plugged	Open and clean.
6. Discharge line plugged	Hand rod discharge line.
7. Counterweight stuck	Packing too tight. Loosen and finger-tighten only.
8. Grease on probes	Clean probes.
9. Faulty switching circuit	Find cause of problem and repair.

Short Cycling of Pneumatic Ejector

Cause:	Procedure and Cure:
1. Inlet check valve leaks and allows liquid to be pumped back into low level manhole causing excess head in manhole	Inspect check valve for foreign matter under valve seat and/or worn seat. Remove, and/or replace.
2. Discharge check valve leaks permitting liquid discharged to flow back to the ejector receiver	Same as above except for discharge check valve.
3. Counterweight too close to guide	Adjust counterweight out further on the lever arm.
4. Packing around float linkage too loose	Finger-tighten packing and check ajustment of counterweight.

Ejector Will Not Fill

Cause:	Procedure and Cure:
1. Inlet check valve or gate valve closed or clogged	Open and clean.
2. Strainer between main valve and receiver clogged and preventing venting of receiver	Clean or replace screen.
3. Air exhaust line clogged	Clean.
4. Sewer plugged upstream from ejector	Clear sewer.
5. No flow in sewer	Discharge water from water truck or fire hydrant into upstream manhole if wish to operate ejector.

RECOMMENDED PREVENTIVE MAINTENANCE SCHEDULE

Daily: Observe several cycles assuring that counterweight action is proper.

Weekly: Hold down counterweight approximately 2 to 3 minutes and check general operation.

Quarterly: Inspect operation of all gate and globe valves.

Semi-Annually: Clean air strainer between ejector receiver and main air valve.

Annually: General inspection of all equipment, cleaning and painting all items as necessary.

Every five years, open 6-inch inspection opening on ejector receiver. Inspect and clean as necessary. Examine inlet and discharge check valves, main air valve and pilot valve.

8.324 Piston Pumps (Fig. 8.19)

Piston pumps are commonly used in high velocity cleaners. The maintenance worker will be required to operate, maintain, and service these pumps. Piston pumps, no matter what manufacturer, operate on the same principle. There is a fluid cylinder, piston, intake valve, and discharge valve. The piston is connected by a rod to a crankshaft. As the crankshaft is turned in a vertical cylinder, the piston travels to the bottom of the fluid cylinder. When this happens, it draws water into the fluid cylinder due to the negative pressure. As the piston travels to the top, it pushes or pumps the water out the discharge valve. A pump may have two fluid cylinders (duplex), three fluid cylinders (triplex), four fluid-cylinders (quadruplex), or five fluid cylinders (quintuplex) and the cylinders may be mounted either horizontally or vertically. The number of fluid cylinders varies with pressure and gallons per minute needed.

Three other factors also determine the pump capacity --- the number of strokes per minute, length of stroke, and diameter of piston or plunger. The larger piston allows more water to enter, and the "Speed" gives it more strokes per minute, therefore,

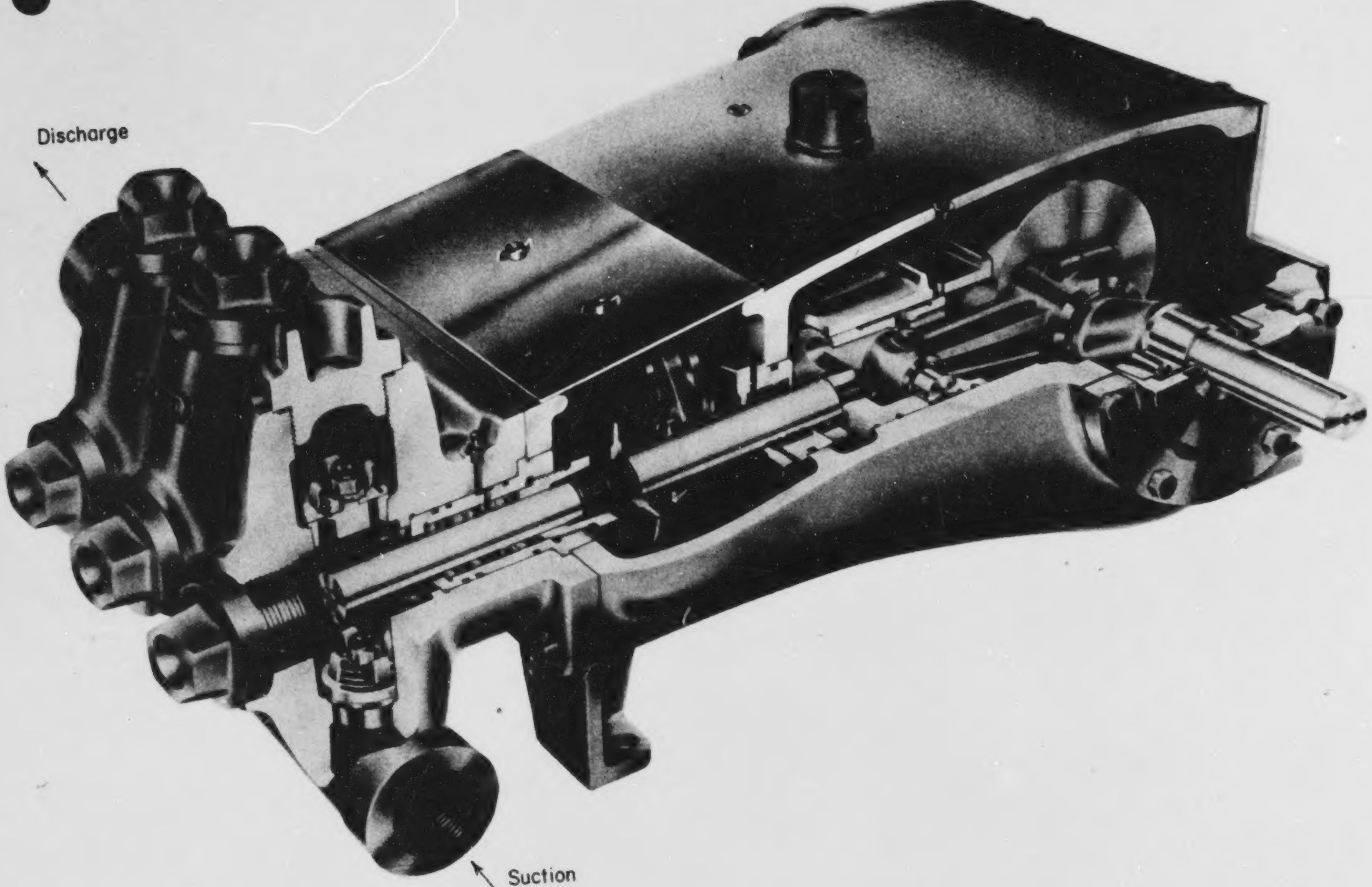

Discharge
Suction

Fig. 8.19. Piston pump on high velocity cleaner. (Courtesy Wheatley Company, Tulsa, Oklahoma)

pumping more water. Unlike a centrifugal pump, the pressure is not determined by the speed. A piston pump is a positive displacement pump. This means that what enters the pump on the suction stroke must be discharged on the discharge stroke, if the valves open and close properly. Because of this, THE DISCHARGE VALVE ON AN OPERATING PISTON PUMP MUST NEVER BE CLOSED. If it is, the pressure will continue to build until the engine is stalled or something breaks. The pressure developed by a piston pump depends on the size of the piston, the force applied to the piston, and the lack of leakage around the valves. Piston pumps should have suction lines at least as large as the pump suction.

On the discharge side of the pump there is a relief valve. This is installed to protect pumps from failure due to excessive pressure. Flows are usually by-passed back to the suction side of the pump when excessive pressures develop. This relief valve must be set according to factory specifications for each particular pump. Failure to have a properly set relief valve can result in loss of life, property, or irreparable damage. Also located on the pump is a pulsation dampener. This is a precharged unit designed to take out the shock of pulsations by the use of an air pocket when the pump is operating. This unit provides longer life to valves, valve springs, and plungers with reduced surges.

Piston pumps also have packing, although it is not usually a problem. They use a hard core packing that must be kept tight at all times and lubricated. The packing is usually greased daily with a lithium base grease, or with water pump grease. Use a manually operated grease gun. If a pressure grease gun is used, the pressure can become too great and you could lose the packing seals. Some pumps of this type are equipped with force feed oilers, and these must be kept full. A universal type packing is sometimes used, and this type packing must be installed so the lips of each sealing ring face the fluid pressure.

Disc or flap valves and valve springs should be inspected periodically for wear. These valves usually consist of a valve seat, valve disc, and spring. The valves can be replaced in most models of pumps, although special tools are required. By removing the valve cover plug the valves can be inspected. Look for broken springs; worn, bent, or broken discs; or seat faces which are corroded, cut, or grooved. Sometimes the discs can be flipped over when worn excessively on one side. Seat faces may show uniform wear and still be satisfactory. The springs and discs are usually easily replaced, but seats require special pullers, mandrels[6] and tools. If you replace seats, take special care not to damage the seating face. This can be done by using an old disc in position over the new seat when tapping it back into the pump body. Valve replacement or repair will be necessary when loss of pressure, volume, or an unusual knocking is noticed.

The crankshaft, pistons, rods, and other parts of the piston pump usually don't cause problems when properly used and maintained. To completely overhaul the pump, each manufacturer's literature must be followed. This requires a high degree of mechanical aptitude and experience, and is not generally done by the maintenance worker.

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[6] Mandrel (MAN-drill). A special tool used to push bearings in or to pull sleeves out.

Maintenance on these pumps require:

DAILY

1. Determine oil level in crankcase
2. Lubricate packing
3. Inspect packing for leakage
4. Keep pump clean

MONTHLY

1. Wash crankcase filter
2. Inspect and tighten all nuts and bolts, if needed
3. Inspect gaskets for oil leaks
4. Thoroughly observe operation of all equipment

SEMI-ANNUALLY

1. Change oil in crankcase
2. Inspect valves
3. Inspect for excessive play in crankshaft bearings and connecting rod bearings
4. Clean and touch up paint

Each manufacturer has lubrication and maintenance brochures and these must be followed for your particular pump.

8.325 Close-Coupled Pumps

Close-coupled pumps differ from the other pumps because the motor and pump are one unit. The motor has an extended shaft and has provisions for mounting the volute surrounding the impeller on the end of the motor. The extended shaft has the impeller mounted on it. On this type of pump there is only one shaft which is the motor shaft; therefore, there isn't any coupling. The pump is running at the same speed as the motor.

The advantages of this pump include the fact that the size permits installation in tight spaces, and it is less expensive than a motor and a pump. Some common uses of close-coupled pumps are in fresh water systems, recirculating water systems and hot water systems.

Close-coupled pumps may have packed or mechanical seals. Mechanical seals probably are more prevalent. These types of pumps are supported by the motor bearings so the only lubrication needed is on the motor. When working on these pumps, special care must be taken to keep the mating flanges clean when assembling so the shaft is properly installed in the housing.

Some of the limitations of this pump are:

1. If the shaft is scored on the pump and can't be repaired, a rotor for the motor must be purchased since it is all one piece.

2. Costs for disassembly and reassembly of damaged motor are more than cost of new pump and motor.

8.326 Submersible Pumps (Fig. 8.20)

The submersible pump is similar to the close-coupled pump in many ways. The motor used is waterproof and mechanical seals are used for keeping out the water being pumped. This pump is completely submersed in the liquid being pumped, and also uses this liquid for cooling the motor. Some older installations require water over the motor at all times. New submersible pumps have thermal switches embedded in the windings to shut off the pump if it gets too hot. These thermal switches must be connected into the control circiut for this purpose.

1. **LIFTING HANDLE**
2. **JUNCTION CHAMBER WITH WATERTIGHT CABLE ENTRIES**
3. **ANTI-FRICTION BEARINGS**
4. **SHAFT**
5. **STATOR WITH TEMPERATURE SENSING THERMISTORS**
6. **ROTOR**
7. **STATOR HOUSING LEAKAGE SENSOR**
8. **BRG. TEMPERATURE THERMISTOR**
9. **SHAFT SEAL**
10. **OIL CHAMBER**
11. **VOLUTE**
12. **NON-CLOG IMPELLER**
13. **COOLING JACKET**
14. **SLIDING BRACKET**
15. **AUTOMATIC DISCHARGE CONNECTION**

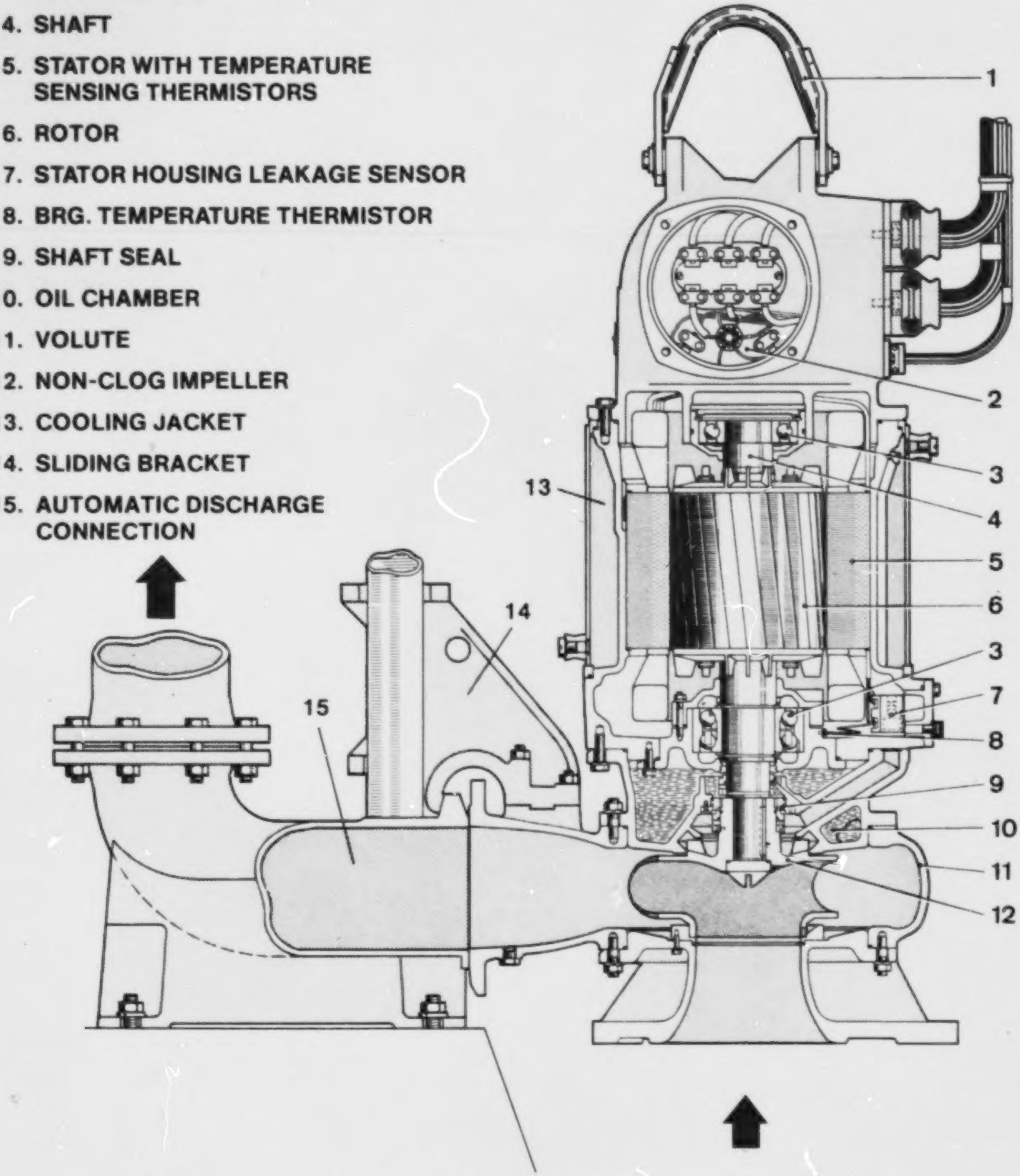


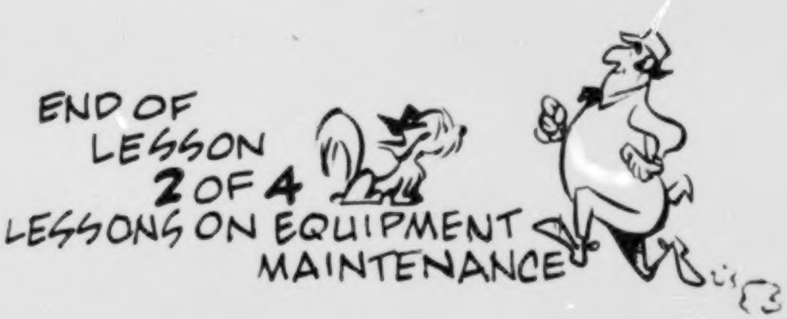
Fig. 8.20. Submersible wastewater pump.

(Courtesy of Flygt Corporation)

Submersible pumps need very little daily maintenance. Since they are submerged in water, you cannot easily get to them for cleaning. They all have mechanical seals so there isn't any packing adjustment. If they become plugged with rags or debris, usually the pump has to be removed from the pit. Some of the newer submersible installations have lifting mechanisms and slide fittings on the discharge so they can be removed without pumping the wet well empty.

One of the limitations with submersible pumps is burn out of the motors. When the mechanical seal starts leaking, water can enter the motor and cause a motor burn out. Repair is very expensive. Proper preventive maintenance can prevent motor burn out and includes:

1. Megger the motor monthly to see if moisture is entering.
2. If the submersible pump ever trips the main circuit breaker, do not reset it until cause is found.
3. Remove the submersible pump on a regular interval and replace the mechanical seal before it fails.
4. Keep grit in wet well to a minimum to reduce wear. Bucket out the grit on a weekly basis if necessary.
5. Take amperage tests every three months to determine if pump is starting to overload. Higher than normal amperage readings can indicate an overload.
6. If the motor operates in an oil bath and has an inspection plug, be sure that the bath is full of oil and not an oil-water emulsion. If the oil is emulsified, the seals are leaking. When this happens, the seals and bearings need attention.



DISCUSSION AND REVIEW QUESTIONS

Chapter 8. Equipment Maintenance

(Lesson 2 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

7. What types of water and material can be pumped by a pump?
8. Why is proper maintenance of a pump important?
9. Why must a pump be in proper alignment?
10. What are the uses of the different types of pumps?
11. Under what conditions would you recommend the installation of a screw pump?
12. What are the advantages of a pneumatic ejector?

CHAPTER 8. EQUIPMENT MAINTENANCE

(Lesson 3 of 4 Lessons)

8.33 Impellers

The heart of a centrifugal pump is the impeller. As stated earlier, this is the device where spinning causes a centrifugal force that pumps the wastewater. There are many different types of impellers, such as,propeller, turbine, mixed flow, and radial. These impellers may be open, closed, or semi-closed. Photographs of different types of impellers are shown in figures 8.21 and 8.22.

The most common impellers used in wastewater centrifugal pumps are semi-closed or closed-type radial for larger pumps and open impellers for smaller sludge pumps. These are used because they will pass solids with less chance of plugging. These impellers require a specific clearance between the pump volute. Generally, for wastewater these clearances are set at .010 to .012 inches. Freshwater pump clearances are approximately .002 to .005 inches. The reason for larger clearances in wastewater pumps is to retard erosion by solid particles such as grit and sand.

Pump impellers should be inspected for wear on a regular basis such as every 6 months or annually, depending on pumping conditions. Before inspecting a pump impeller you should:

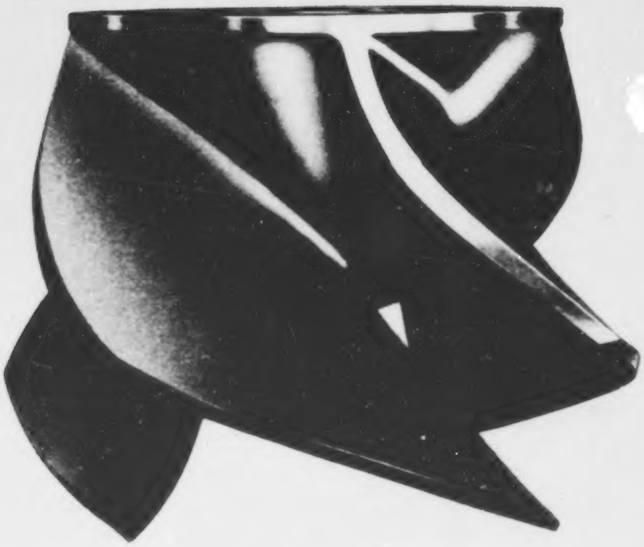
1. Turn off and lock out all electrical power to pump. "Main Circuit Breaker" and "Start-Stop Station." (Don't lose a finger or arm.)

2. Tag control panel with a "Do Not Start" tag stating time, date, and your name or initials.

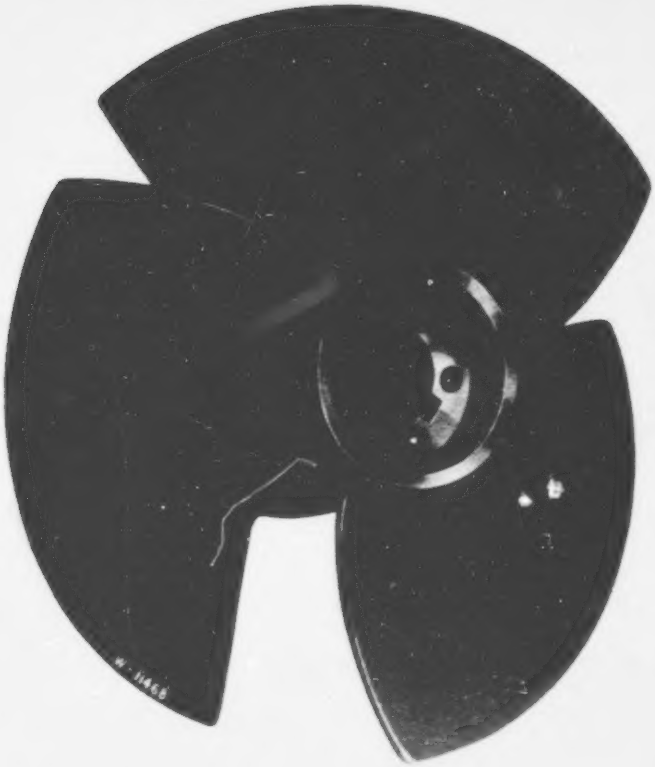
3. Close suction and discharge valves (do not depend on discharge check valve.)

4. Drain pump with bolts still in handhole cover until water stops. (Many a lift station has been flooded because something prevented a valve from closing). If bottom of volute has a drain, use it.

1025



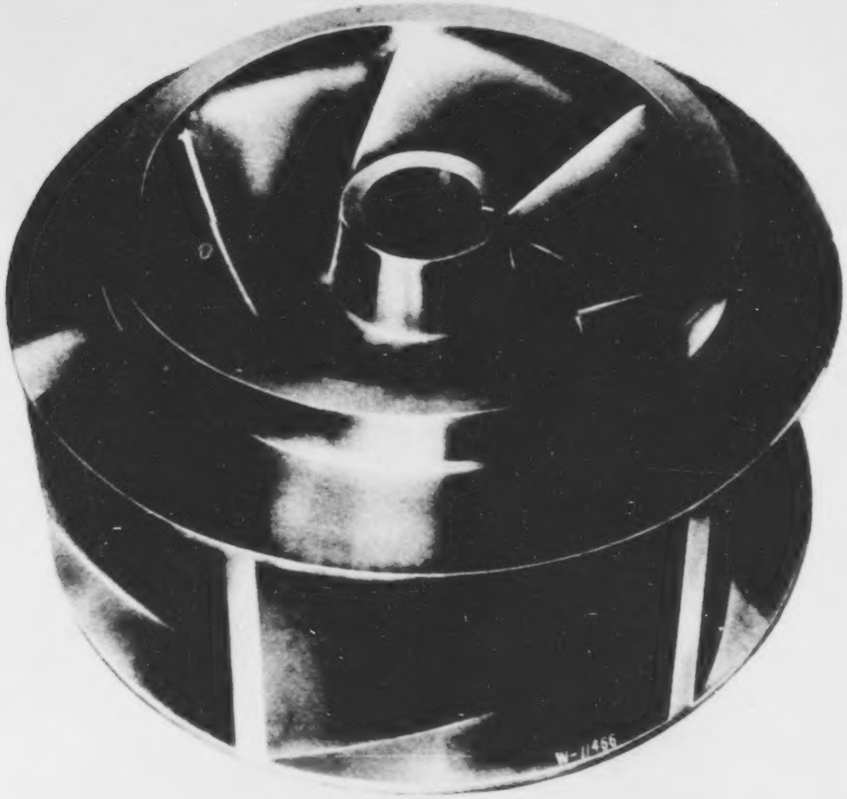
Mixed Flow



Propeller

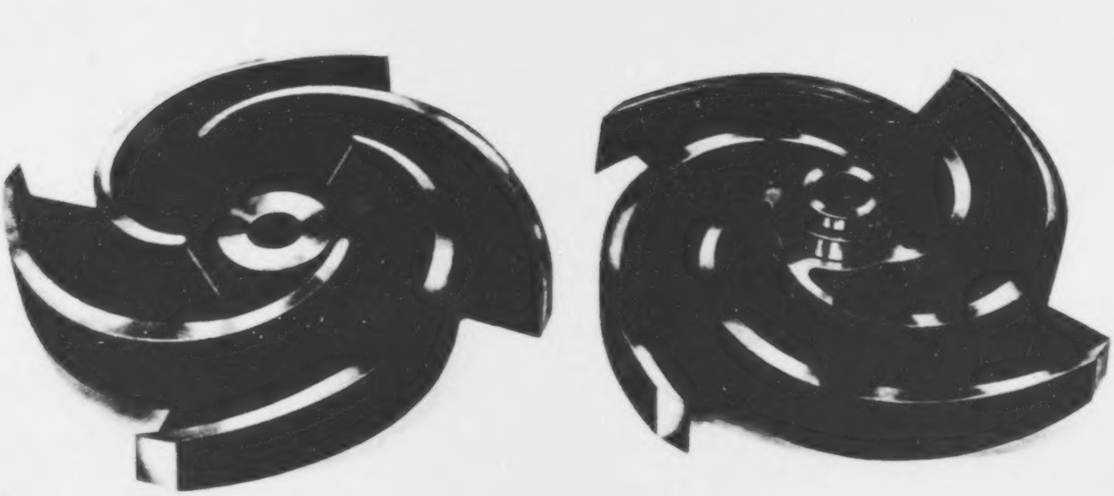
Fig. 8.21. Impellers

(Source: *Centrifugal Pumps* by Karassik and Carter of Worthington Corporation)



Closed Radial

(Closed radial impellers are used in wastewater treatment plants.)



Open Radial

Fig. 8.22. Impellers

(Source: *Centrifugal Pumps* by Karassik and Carter of Worthington Corporation)

5. Open handhole covers and visually inspect for foreign objects which will injure you (razor blades, sharp objects, needles in rags). Turn the shaft by hand and listen for loose objects. Inspect for binding by rags, rope or metal. Use a special hook or tool to remove trash, but not your hands. When the area is clear, the insides can be inspected.

When inspecting a pump impeller you should look for:

1. Cavitation marks. They appear as holes, indentations, bullet chips, and cracks.
2. Chips, broken tips, corrosion, unusual wear.
3. Tightness on shaft. Hold shaft and try to wiggle impeller, inspect impeller nut. Pry with wood up and down.
4. Clearances. This is done by inserting a feeler gage between pump volute or faceplate and impeller if the pump does not have wearing rings. With wearing rings, clearance is adjusted between wearing rings on the impeller and volute faceplate.
5. Wearing rings on impeller and volute.
6. If impeller is rubber coated, look for tears or bubbles in coating.

If any of the above problems are noticed, your supervisor should be notified and it should be noted in the equipment file for that pump.

Excessive clearances can cause frequent plugging, excessive power usage, and loss of pump capacity. Many pumps have impellers which can be adjusted fairly easily. One method is removing shims from the upper bearing housing or between the upper bearing and shaft. Another method used is a threaded bearing assembly which can be loosened and screwed up and down. Still another method is shimming impeller or faceplate. You will have to consult your pump manual for the particular method to be used on your pump.

Many wastewater pumps are fitted with wearing rings on the impeller and volute, or faceplate. These wearing rings are installed so they take the wear rather than the impeller or volute and are replaceable. In other words, they protect the impeller and pump casing from damage due to excessive wear by solids and grit. These wearing rings are made of materials such as bronze, stainless steel, and Teflon. They are fabricated and installed so that they can be replaced when worn, thus not having to replace the entire impeller or volute. Wearing rings are usually pressed or pinned on the impeller and volute. Sometimes they are threaded with a set screw holding them. The pump manufacturer's literature will inform you what type is installed in your particular pump. Wearing rings must be replaced when worn excessively or when clearances between impeller and volute cannot be attained. Be sure to replace them before they become worn through or wear starts on volute or impeller, because new wearing rings will not fit properly on worn down volutes or impellers.

In order to replace wearing rings it is necessary to dismantle the pump head from the volute. The worn rings are removed by chiseling, cutting, or grinding off. When the impeller is removed, a new wearing ring can usually be pressed on under a press. Another method is to heat the wearing ring in hot oil and tap over impeller with a block of hard wood after it has expanded. Make sure the wearing ring is installed completely and do not scarf or burr a new ring with metal punches or drift pins. If burred, file off before installing in volute.

The volute wearing ring can sometimes be installed by pressing or tapping. It is much easier to freeze the wearing ring with dry ice, shrinking it, and dropping or tapping it into place with wood or plastic drift. Before installing either wearing ring, make sure mating surfaces are clean and free of nicks and burrs. Also be sure the wearing rings are properly seated into the intended position.

The replacement of wearing rings is generally done by qualified mechanics and special tools are required. Since the pump has to be removed and dismantled, special tools are required such as hoists, presses, chains and slings, punches, chisels, wrenches, and power tools. Care must be used to prevent damage to pump or parts being repaired.

Cavitation is caused by the pump operating at conditions different from those for which it was designed, such as operating off design curve, poor suction conditions, high speed, air leaks into suction end, and water hammer conditions. Many of these are not controlled by the maintenance workers, but some items can be checked.

1. Make sure suction valve is all the way open. Never throttle a suction valve.
2. Examine wet well level and insure pump is not sucking in air or pumping too low before shutting off. Also look and be sure pump is not picking up air by vortexing (whirlpools) at inlet of suction line.
3. Inspect suction line to make sure it is not partially plugged with grease or foreign material such as sand, grit and rocks.
4. Inspect bottom of wet well for grit deposits.
5. Examine maximum speed setting on pump to determine if correct.
6. Look for places where air could be leaking in at packing.

Worn, broken, chipped, or damaged impellers can be repaired only by welding, machining, or replacing. This will require the services of a mechanic with expertise in pump repair.

Loose or unbalanced impellers should be repaired by a mechanic immediately and before further damage to the pump occurs. If a pump is left in this condition, the shaft could break and the pump could be damaged beyond repair. Unbalanced impellers may vibrate, fracture and possibly rupture the volute. Impellers must be dynamically balanced after any repair work.

QUESTIONS

8.33A How often should impellers be inspected for wear?

8.33B What is the purpose of wearing rings?

8.33C What can happen if clearances are not kept in proper adjustment?

8.33D How can you tell if an impeller has damage from cavitation?

8.33E What causes cavitation?

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8.34 Shafts

Pump shafts are used to turn the impeller, mount the bearings, and are connected to a pump driver of some type. These shafts are generally fabricated from an alloy steel machined to size. They are machined to exact tolerances and must be maintained this way for proper operation. There are four major areas to a shaft:

1. Impeller end
2. Coupling end
3. Bearing fits
4. Stuffing box area.

The impeller end is where the impeller is pressed, keyed, or secured on to the shaft. This part of the shaft is usually not a problem to maintain. If the impeller is kept tight, there should never be a need to repair this shaft area during regular use.

The coupling end is where the coupling mounts on the shaft to connect to the driver, and is usually never in need of repair. When removing or installing a coupling, the coupling end should be cleaned thoroughly and lubricated. Rust can sometimes be a problem and must be removed.

Bearing fits or journals are where the bearings are installed on the shaft. These are designed to have press fit tolerances as specified by the pump manufacturers. They are not usually a maintenance problem unless a pump with a bearing which has failed is left running for an extended time. If this happens, the inner race of the bearing could turn or spin, thus damaging the bearing fit. If this happens, it will be necessary to remove the shaft and have it metal sprayed and ground down to size by a machine shop. The machine shop will need to know the bearing number so they can machine the shaft to proper size. Bearings are discussed in Section 8.37, Bearings.

The most important problem section with a pump shaft is the stuffing box area. The pump packing, if not properly cared for, will cut grooves into the shaft in this area. Some of the reasons for grooves being cut into the shaft are:

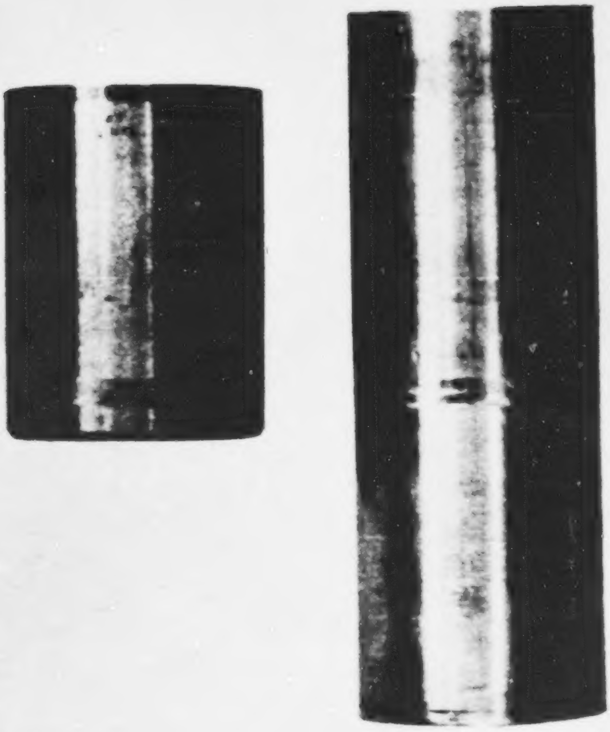
1. Packing glazed when pump was started.

2. Worn packing that allows leakage from the volute when pump is operating. This leakage can carry grit or other foreign solids into the stuffing box.

3. Dirty seal flushing water.
4. Water seal pressure set too low or plugged.
5. Wrong type packing.
6. Shaft sleeve (seal cage) slipping.
7. Improper packing adjustment, such as packing too tight.

Two very acute problems arise when this happens. The first thing is that once the shaft is scored or grooved, packing will not last. The grooves will rip and tear out new packing in a very short time. The second problem is the shaft is weakened and, if left, will be damaged beyond repair.

Manufacturers have realized the wear problem with the shaft in the stuffing box area and designed shaft sleeves (Fig. 8.23) to avoid this problem. Shaft sleeves are installed over the shaft in the area on the shaft where it passes through the stuffing box. These sleeves are usually made of stainless steel, chrome or ceramic plated alloy steel, bronze, or other materials suitable for the pumping application. The shaft sleeve is either keyed on, pressed on, threaded on, or held by the impeller. Shaft sleeves are designed to protect the shaft by taking the wear from the packing. To replace a complete shaft is very costly compared to a shaft sleeve. Shafts and/or shaft sleeves should be inspected every time the pump is repacked. This inspection has to be done when the pump packing is removed and stuffing box cleaned out. In order to see the shaft sleeve it might be necessary to use a small mirror, such as dental mirror, and flashlight. Inspect for grooves, split shaft seal and any other unusual conditions. The sleeve should be repaired or replaced when grooves are observed. It must be replaced before wearing through to the shaft. To replace the shaft sleeve, it is necessary to remove and dismantle the pump. Usually, just the impeller needs to be removed and the sleeve can be pulled off.



NOTE:

Also see Figure 8.14, and Figure 8.15 for location of shaft sleeve on pump shaft inside of stuffing box.

Fig. 8.23. Pump shaft sleeves. (Courtesy Worthington Corporation)

Some shaft sleeves are extremely difficult to remove and they can be damaged so repair is impossible. Try heating the sleeve and/or freezing the shaft to break bond and increase clearance. Shafts and shaft sleeves can be repaired by metal spray, ceramic spray, or chrome plating. This method may cause problems because, if not properly done, it will cause distortion. If a sleeve is worn, it should be replaced.

Replacing a shaft or shaft sleeve requires specialized tools and competent workers with a thorough knowledge of pumps and mechanics The maintenance worker usually does not replace a shaft or shaft sleeve.

QUESTIONS

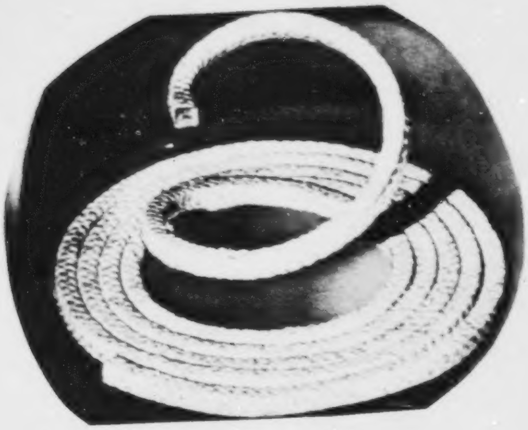
8.34A How can pump shafts be protected from damage?

8.34B When should a pump shaft sleeve be repaired or replaced?

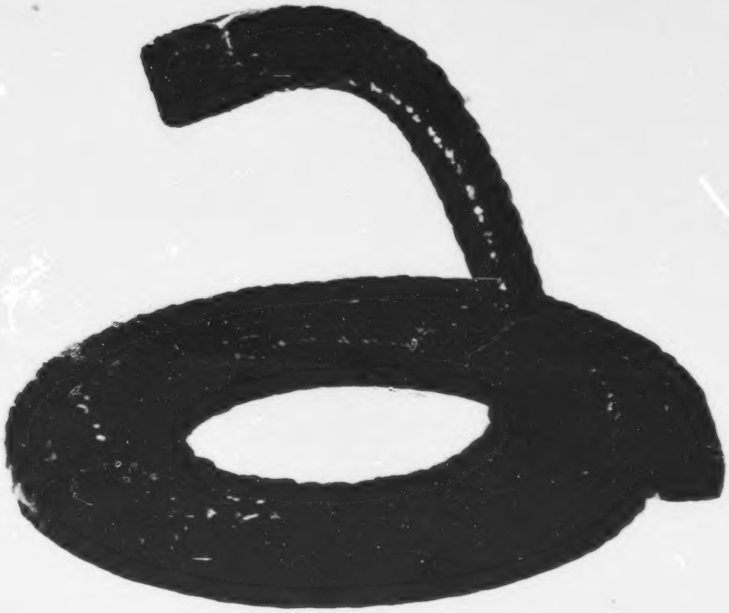
8.35 Packing (Fig. 8.24)

Packing is probably the single biggest problem for the maintenance worker maintaining pumps. More pumps have been damaged due to improper maintenance of packing than any other reason. If packing is not maintained properly, the following troubles can arise:

1. Loss of suction due to air being allowed to enter pump.
2. Shaft or shaft sleeve damage.
3. Water or wastewater contaminating bearings.
4. Flooding of pump station.
5. Rust corrosion and unsightliness of pump and area.



Teflon Packing



Graphite Packing

Fig. 8.24. Packing
(Courtesy A. W. Chesterton Co.)

Packing is used to provide a seal where the shaft passes through the pump casing in order to keep air from being sucked into the pump and/or the water being pumped from coming out.

There are probably over 500 different types, grades, manufacturers, and styles of packing on the market today. Packing can be round, square, loose, pointed, or almost any size, shape or form. It is manufactured from jute, hemp, Teflon, asbestos, rubber, lead, and many other materials too numerous to mention. The pump manufacturer should recommend the proper packing on the basis of the following:

1. Type of pump and manufacturer's recommendation.
2. Material being pumped (water - wastewater - acid - alkali - scum - sludge - grit - and others).
3. Temperature of liquid being pumped.
4. Grease or water flushing.
5. Peripheral (outside) speed of shaft.

Do not pick a cheap grade of packing due to price because it will cost you more in the end when shaft sleeves are damaged or time required to repack. Generally, in wastewater pumps, braided asbestos material is used; it can be graphite impregnated, Teflon coated, or of a similar material.

Let's start our packing procedure by placing a new wastewater centrifugal pump into service. The first consideration is to determine if the packing installed at the factory is still good. Since it arrived on the job site in February and wasn't installed until August, we must assume that it has been setting for at least seven months in the weather. The contractor had some plastic over

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it, but it finally blew off. The packing has been rained on, the wind blew dust over it, and now it's 101°F outside so it's baked. If not, to make matters worse, you notice that the painter has helped by coating the pump (name plate included) with one coat of primer and two coats of enamel. Okay, let's repack the pump before we start it and not ruin the shaft sleeve. Also we better make sure the shaft and the rest of the pump are ready to go after sitting outdoors before we start the pump. Get the manufacturer's literature and study it.

1. Turn off the main circuit breaker for this pump and control switch.

2. Lock it in the OFF position and tag it OFF (fill out a card with date and initials).

3. Close suction and discharge valves.

4. Drain pump by loosening bolts on handhole cover. DO NOT REMOVE BOLTS COMPLETELY UNTIL PUMP STOPS DRAINING AND YOU ARE SURE THAT THE SHUT OFF VALVES ARE HOLDING. If available, drain pump by using drain valve or plug at bottom of volute.

5. Remove packing gland nuts and/or bolts and remove glands. These are usually split for removal. If the packing gland is not split for removal, it has to be backed off on the shaft. Provide room for removal and replacement of packing.

6. Remove packing. The packing rings can be removed by screwing a packing hook (Fig. 8.25) into them and pulling out. Sometimes it helps to revolve the shaft while pulling. Care must be taken while using the packing hook that the shaft isn't scored or nicked.

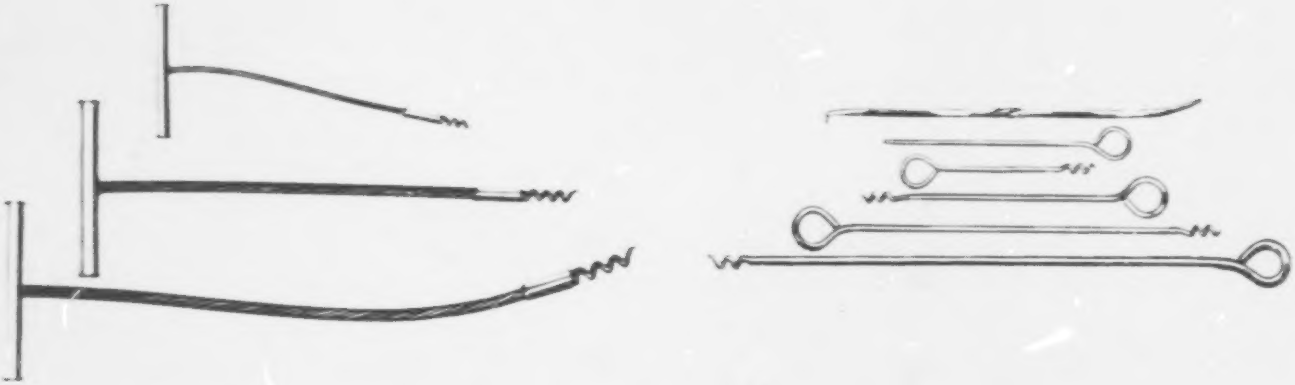

Fig. 8.25. Packing hooks.
(Courtesy A. W. Chesterton Co.)

7. After you have removed the top rings of packing, the lantern ring (seal cage) must be removed. This can usually be fished out with a heavy piece of wire, coat hanger, or welding rod. Some have a threaded hole in which a 1/4-inch bolt can be inserted. If the pump has been in service for awhile, you will have to clean around the shaft and stuffing box to get it out. Try tapping with a wooden dowel to loosen it up if you are still having trouble removing it. Always remove it. These also are usually split so they can be removed from the shaft.

8. Next, remove the remaining packing rings according to the manufacturer's drawing. They are usually more difficult to remove after a pump has been in service.

9. Wash all parts with soap and water and scrub with a wire brush, if necessary. Thoroughly clean inside the stuffing box and the shaft. Wipe parts dry.

10. Disconnect seal water line or spring grease cup. Clean thoroughly and inspect its operation.

11. Make sure that seal water hole through stuffing box is clear and clean.

12. Inspect shaft or shaft sleeve for wear and cleanliness. Make sure that the lantern ring was positioned properly and the manufacturer's print was correct. If the number of rings of packing to be installed before the lantern ring is unknown, insert enough packing so that the lantern ring is correctly positioned with the seal water or grease inlet when the packing has been pushed into the recess as far as it will go. Each packing ring should be cut to fit the shaft.

13. Determine packing requirements.

    A. Determine packing size. Measure from outside of shaft to inside of stuffing box with a scale. Whatever the measurement is, this is the size of the packing. Let's assume this is 1/2 inch; therefore, 1/2-inch square packing is used.

    B. Measure the depth of the stuffing box, outside face to inside bottom. Let's assume this measurement is 4 inches.

    C. Measure from bottom of stuffing box to center of seal water inlet. Let's assume this is 1-3/4 inches.

    D. Measure lantern ring or seal cage, and again, let's assume this is 1/2 inch.

    E. With a 4-inch depth and subtracting the 1/2-inch seal cage, we have 3-1/2 inches that can be filled with packing. 3-1/2 inches divided by 1/2 inch (size of packing) allows us 7 rings of packing to be inserted.

    F. The seal cage should be located in the stuffing box so that it is centered where the seal water or grease enter. Take the seal cage measurement and divide it in half. 1/2 inch divided by 2 equals 1/4 inch. The measurement from the bottom of stuffing box to center line of seal water inlet was 1-3/4 inches. By adding 3 rings of 1/2-inch packing (which equals 1-1/2 inch) and adding the 1/4 inch for seal cage, we arrive at 1-3/4 inches, which puts the seal cage at the seal water inlet.

As stated earlier, this information usually can be taken from the manufacturer's literature.

Now that we know the size of packing, number of rings needed, and where to position the seal cage (lantern ring), we can start repacking the pump.

Packing should be kept in a clean place. Never allow the protective wrapping to be left off or the box uncovered. Do not allow packing to come in contact with solvents or high temperatures which could force lubricant out of it. Discard any packing that has become contaminated with dirt, sand, grit, or other foreign material.

14. Packing the pump.

    A. Cut packing to proper length using a very sharp knife, and on a clean board.

        1. If proper length is not known, wrap around a mandrel of the same size as the shaft, or wrap around the shaft itself, and cut.

        2. Make clean cuts, no ragged edges.

        3. If possible, cut packing on shaft so parallel ends can be obtained.

        4. Cut all necessary rings at one time.

    B. Roll packing flat with short pipe on a clean bench, or tap slightly so it will fit into the stuffing box more readily.

    C. Wrap the new packing rings (one at a time) around the shaft and insert into the stuffing box, keeping joints together. Tap into place with gland or a split wooden bushing.

D. Stagger the joints or butts of the packing around the shaft. For example:

   1. First ring -- place butt or joint on right side of shaft.

   2. Second ring -- place butt or joint on left or opposite side of shaft.

   3. Third ring -- place butt at top of shaft.

   4. Fourth ring -- place butt at bottom of shaft.

   5. Repeat procedure for more rings.

E. Position the lantern ring (seal cage) so it is centered in the seal flush opening. Remember the ring moves back deeper into the box as packing is tightened.

F. Install the three packing rings. Stagger the joints in the same sequence as the first three rings.

G. Install packing gland keeping the gland square at all times.

   1) The last ring of packing may have to be left out and installed after the packing is seated.

   2) Tighten packing gland just enough (hand tight) to prevent excessive leakage before starting the pump.

Starting new or repacked pump:

1. The first thing we must do is make a visual inspection. Look for loose nuts and bolts, guards left off, tools left around, and any other unusual condition.

2. Open suction and discharge valves. Make sure they are completely open.

3. Turn on seal water or make sure grease cups are full.

    a. Seal water can be either fresh water from an air gap system or recycled filtered water.

    b. Seal water pressure should be adjusted to 5 psi higher than the maximum pump discharge pressure.

4. Prime pump by venting air or filling pump case with water from a hose or a bucket.

5. Remove electrical lock out tag and unlock main circuit breaker.

6. Start pump and observe its operation.

    a. Inspect gages to see if pumping.

    b. Listen for any unusual noises.

7. Adjust packing gland.

    Probably more packing jobs are ruined by improper gland adjustment than for any other single reason.

    a) Tighten the packing gland just enough to prevent excessive leakage.

    b) As the packing adjusts itself to the shaft, tighten the gland slowly one half turn at a time on each nut, keeping gland square until the leakage is reduced to the desired number of drops per minute.

        1) Leakage of 20 to 60 drops per minute is desired.

        2) Pumps with grease lubrication should not leak, but do not overtighten.

        3) Keep packing gland square with pump shaft to prevent rubbing on shaft. To keep gland square, hand tighten first bolt until slack is taken up. Insert other packing gland bolts and tighten to point of first resistance. Next tighten each bolt one flat at a time on alternate sides to insure an even take up until the leak rate is properly adjusted. Uneven take up jams the packing and the shaft.

Usually the gland is not pulled up more than finger tight to maintain the proper leakage. If the gland becomes too hot to touch, it is pulled up too tight.

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Stop the pump and allow the packing to cool, then readjust it. Do not back off on gland while pump is running because entire set of packing will move out, not relieving any pressure on the shaft. Start the pump and determine gland temperature. It may be necessary to start and stop the pump several times before desired leakage and temperature are obtained. Small motors may be stopped and started several times in a short period, but severe motor damage can occur in large motors when there are excessive starts and stops within a given period. Inspect seal water again and make sure it is entering packing. Clean filters and strainer as necessary to maintain flushing water supply to packing gland. If one ring of packing was left out, be sure and install it when packing is sealed. Below are some causes of shaft packing failures provided Courtesy of A. W. Chesterton Company.

A used or worn set of packing can be of value as it often indicates cause of premature packing failure. Examine same carefully. The following tabulation should be helpful in tracking down packing troubles.

INDICATION	SUGGESTIONS
No leakage at start up.	Back off gland to encourage generous leakage. If negative suction, install lantern and connect to discharge.
Excessive leakage at start up.	Check for correct packing size. Were rings installed correctly in accordance with instructions Check pump for run-out.
Packing rings flattened out on I.D. under the rod or shaft.	Check bearings. Packing probably supporting the shaft weight.
Packing rings flattened out above rod or shaft, or on either side of same.	Check alignment of shaft. Worn bearings may be causing whip or run-out.
Distinct bulge on side of ring.	Probably too wide a gap on adjacent ring — rings cut too short.
Sides of rings shiny or worn.	Rings may be too loose and are rotating with the shaft.
Rings extruding past gland follower.	Too much clearance between O.D. of shaft and I.D. of follower. Apply bushing. May also be excessive gland pressure.
Top or gland end rings in poor condition, bottom rings O.K.	Set improperly installed.
Rings disappear in set.	Packing entering the system. Install bottom bushing.
Packing is torn.	Check sleeve for burrs. Are there any abrasives?
Rings are burned, faces dried and charred.	Check for proper size packing. Is packing the correct selection with respect to heat limitations and/or peripheral speed? Check lubrication. Are there any abrasives?
Packing hardens.	See "burned rings" above. Are there congealing liquids involved?
Packing softens.	Check for proper style selection, also for lubrication.
Excessive loss of lubricant.	Excessive gland pressure. Check for packing selection, temperature, whip in shaft.
Unexplained leakage.	Shaft sleeve may be leaking. Replace sleeve seal under sleeve.
Packing freezes to shaft after shutdown.	Liquid salting out or congealing in packing set. Provide lubrication to packing before shutdown.

QUESTIONS

8.35A What is the purpose of packing or mechanical seals?

8.35B What is the purpose of the lantern ring?

8.36 Mechanical Seals (Fig. 8.26)

Many pumps use mechanical seals in place of packing. Mechanical seals serve the same purpose as packing; that is, they prevent leakage between the pump casing and shaft. Like packing, they are located in the stuffing box where the shaft goes through the volute; however, they should not leak. Mechanical seals are gaining popularity in the wastewater field.

Mechanical seals have two faces which mate that prevent water from passing through them. One half of the seal is mounted in the pump or gland with an "O" ring or gasket, thus providing sealing between the housing and seal face. This prevents water from going around the seal face and housing. The other half of the mechanical seal is installed on the pump shaft. This part also has an "O" ring or gasket between the shaft and seal to prevent water from leaking between the seal part and shaft. There is a spring located behind one of the seal parts which applies pressure to hold the two faces of the seal together and keeps any water from leaking out. One half of the seal is stationary and the other half is revolving with the shaft.

Materials used in the manufacture of these seal parts are carbon, stainless steel, ceramic, tungsten carbide, brass, and many others. The different type materials are selected for their best application. Some of the variables are:

1. Liquid and solids being pumped.
2. Shaft speed.
3. Temperature.
4. Corrosive resistance.
5. Abrasives.

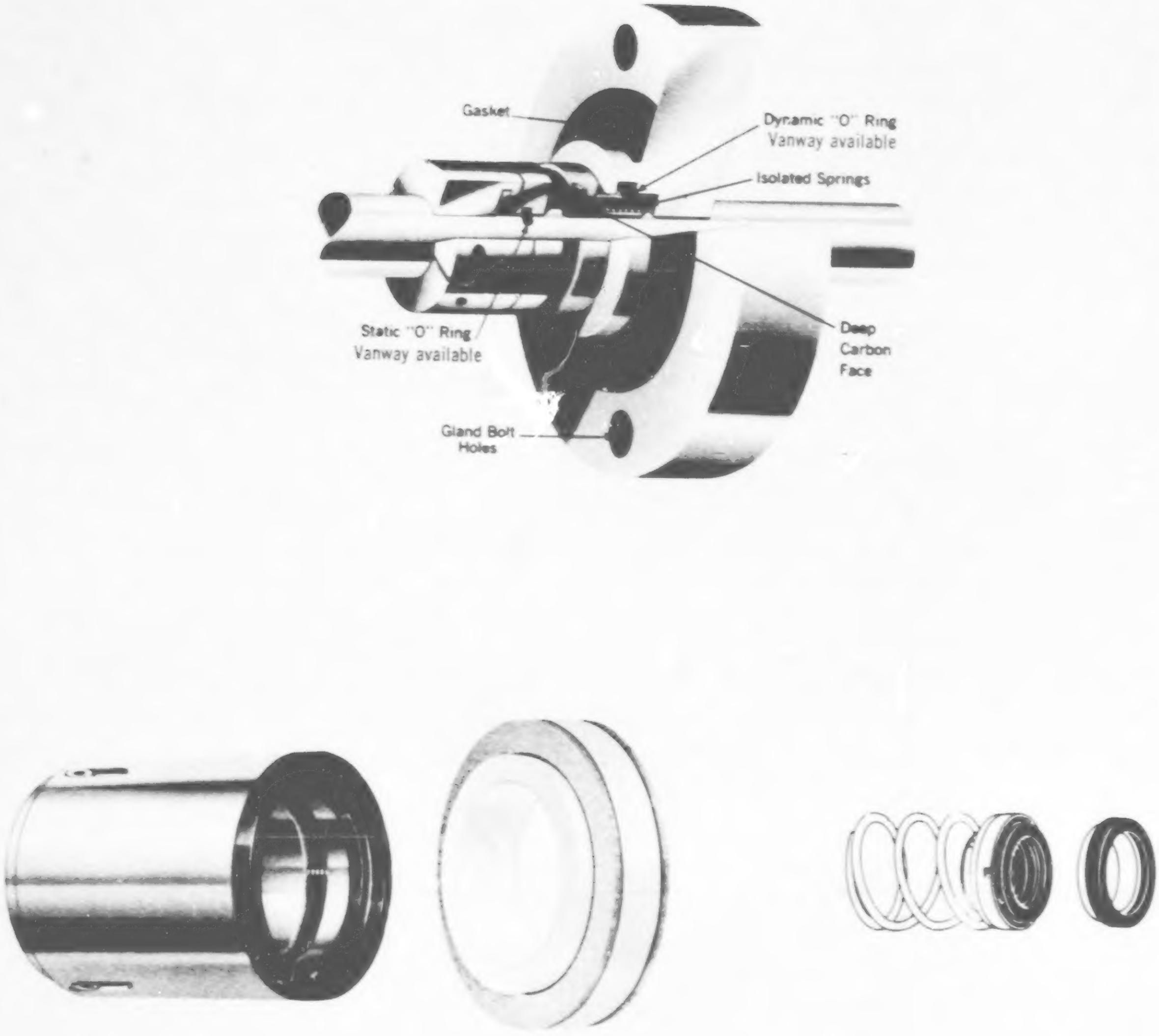
Gasket
Dynamic "O" Ring
Vanway available
Isolated Springs
Static "O" Ring
Vanway available
Deep
Carbon
Face
Gland Bolt
Holes

Fig. 8.26. Mechanical seals
(Courtesy A. W. Chesterton Co.)

Initially, mechanical seals are much more expensive than packing to install in a pump. This cost is gained back in operating costs during a period of time.

Some of the advantages of mechanical seals are as follows:

1. They last from three to four years without having to touch them, resulting in labor savings.
2. Usually there isn't any damage to the shaft sleeve when they need replacing. Expensive machine work is not needed.
3. Continual adjusting, cleaning, or repacking is not required.
4. The possibility of flooding a lift station because a pump has thrown it's packing is eliminated; however mechanical seals can fail and flood a lift station too.

Some of the limitations of mechanical seals are as follows:

1. High initial cost.
2. Competent mechanic required for installation.
3. When they fail, pump must be shut down.
4. Pump must be dismantled to repair.

Mechanical seals are always flushed in some manner to lubricate the seal faces and minimize wear. This may be the liquid being pumped if it is fresh water. If fresh water is used, it is connected from the high pressure side and back to the stuffing box low pressure side. In some lift stations where fresh water is not available, the wastewater is used in this manner but it must be filtered. Another method is to use fresh water from an air gap system. Still another way of lubricating the seal is to use a spring loaded grease cup.

Whatever method is used, it must be inspected frequently. The seal water is adjusted to 5 psi above maximum discharge pressure to keep the wastewater and grit from entering the seal housing and contaminating the seal faces. Grease cups must be kept full at all times and inspected to make sure they are operating properly.

When a pump is fitted with a mechanical seal, it must never run dry or the seal faces will be burned and ruined. Mechanical seals are not supposed to have any leakage from the gland. If a leak develops, the seal may require relapping or it may have to be replaced.

Repair or replacement of mechanical seals requires the pump to be removed and dismantled. Seals are quite delicate and special care must be taken when installing them. Mechanical seals differ widely in their construction and installation; and individual manufacturer's instructions must be followed. Due to the complexity of installing mechanical seals, special tools and equipment are needed as well as a qualified pump mechanic.

QUESTIONS

8.36A Why should a pump with a mechanical seal never be allowed to run dry?

8.36B What should be done when a mechnical seal develops a leak?

8.37 Bearings

Pump bearings usually should last for years if serviced properly and used in their proper application. There are several types of bearings used in pumps such as ball bearings, roller bearings, and sleeve bearings. Each bearing has a special purpose such as thrust load, radial load, and speed. The type of bearing used in each pump depends on the manufacturer's design and application. Whenever a bearing failure occurs, the bearing should be examined to determine the cause and, if possible, to eliminate the problem. Many bearings are ruined during installation or start up. This section is a guide to identify types of bearing failures, causes, and preventive measures.

Bearing failures discussed are:

1. Fatigue failure
2. Contamination
3. Brinelling[7]
4. False brinelling
5. Thrust failures
6. Misalignment
7. Electric arcing
8. Lubrication failure
9. Cam failure

The following section is published with the permission of the Fafnir Bearing Company, Division of Textron, New Britain, Connecticut, from a publication on "How to Prevent Ball Bearing Failures."

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[7] Brinelling. Tiny indentations high on the shoulder of the race.

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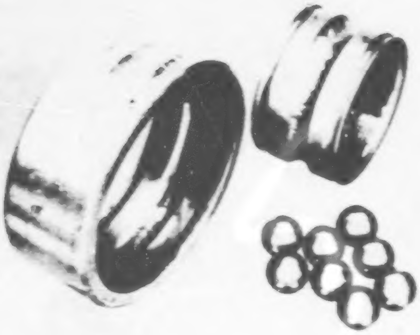
FATIGUE FAILURE

1. IDENTIFICATION



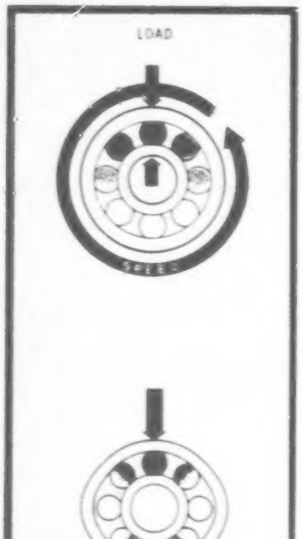
FLAKING OR SPALLING OF RACEWAY

Spalling is caused by a granular weakening of the bearing steel. The failure begins as a small fracture of the steel's internal structure. This fracture progresses to the surface of the race where particles of metal flake away as shown in the photograph.

NOISY RUNNING OF THE BEARING

Because of the rough race surface and the loose metal chips, there will be an increase in bearing vibration and noise.

2. CAUSE



NORMAL DUTY

As outlined in the introduction, a bearing has a life expectancy which depends upon load and speed. Calculations, based upon laboratory testing and field experience, have been set up to determine, fairly accurately, the life span of a group of bearings of a given size. The fatigue failure, as outlined above, is the result of a bearing "living out" its normal life span. The flaking of the races is caused by the combined effect of load and speed. In any rotating or oscillating ball bearing, there is a constant flexing or deflection of the ring and ball material under the load. Speed determines how often the flexing occurs while load determines the actual amount of stress under which the bearing steel operates. Assuming good machine design, satisfactory lubrication, and sound maintenance practices, it is load and speed that will, over a long period of time, cause eventual failure.

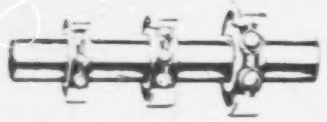
OVERLOAD ON THE BEARING

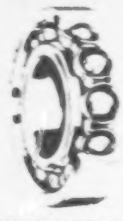
Premature failure of the bearing may result from the bearings being either radially or axially loaded beyond its normal capacity. Excessive operating load is not, however, the only reason for bearing overload. Overload may also occur due to abusive operating conditions as outlined below:

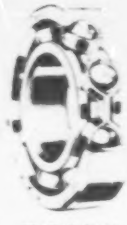
1. If a bearing with insufficient internal clearance (the space between balls and races) is mounted on a shaft with an excessively heavy press fit, the bearing will operate with increased friction and torque. This is because, with the outer-ring held firmly, the inner ring has been expanded, "pinching" the balls between the two rings.

2. If the bearing housing is out-of-round, the outer ring will tend to conform to the shape of the housing. This will exert a localized pressure on the ball contact area in addition to the normal pressure imposed by the operating work load.

3. PREVENTIVE MEASURES




MAXIMUM CAPACITY TYPE


CONRAD TYPE

FOR NORMAL FATIGUE FAILURE

In the case of normal fatigue failure, the bearing has lasted its expected life. The remedy is simply to replace the bearing.

OVERLOAD FAILURE

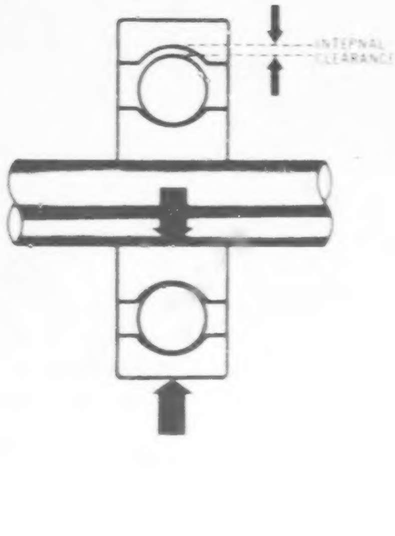
Where overload is the cause of a premature fatigue failure, several alternatives are open:

1. Redesign to permit incorporating a bearing with greater capacity. There are extra-light, light, medium, and double row series bearings available in the same shaft sizes. The heavier series have thicker ring sections and larger balls for greater capacity. Also available for higher radial capacity is the maximum capacity type of bearing. This has exactly the same dimensions as the standard deep-groove Conrad type with the added advantage of more balls which are introduced through loading slots in the rings. These extra balls give this bearing increased radial capacity but the loading slots ground into the races restrict the thrust capacity of the bearings.

2. The load may be decreased to prolong the life of the bearing.

3. Housings should be gaged for out-of-roundness and machined or ground to proper symmetry and size. This insures that the outer ring will not be "pinched" or "squeezed" resulting in an overload condition.

4. If the failure is caused by an overload imposed by inner ring expansion, either the shaft fit may be made looser by regrinding it to proper size or, in the event of thermal expansion, a bearing with looser internal fit (more clearance between balls and rings) may be recommended.



CONTAMINATION

1. IDENTIFICATION

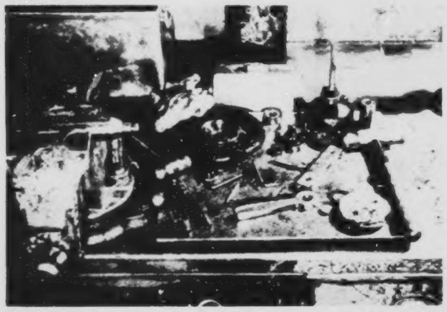
◂ SCORING, PITTING, SCRATCHING

In a failure caused by the entrance of contaminants into the bearing, there may be a number of identifying earmarks. Where larger particles of dust or dirt are present, there will be scratches and pits around the periphery of the race with corresponding scoring of the ball. Where the contamination is in the form of very fine abrasives such as glass powder, graphite, or dust impregnated lubricants, the impurities will act as a lapping agent altering the appearance of balls and raceways. This type of failure may be characterized by intermittent noise in the bearing. The actual presence of dirt in the bearing is the best indication of this type of failure.

RUST ▸

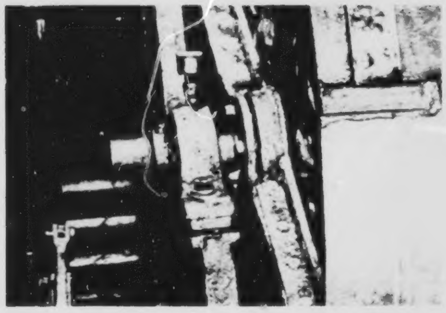
Where rust forms on the O.D. of the outer ring, it will not usually interfere with the bearings' operation in standard application, but rust in the bore is more serious because of the importance of inner-ring-to-shaft fit. Rust in the raceways or on the ball surfaces precludes any further usage of the bearing.

2. CAUSE



DIRTY OR DAMP SURROUNDINGS

Most bearing failures may be traced to some sort of contamination. Dirty working conditions are one of the bearing user's greatest problems. Thousands of dollars a year may be saved simply by taking certain precautions (outlined below) against the entrance of impurities into bearings. Internal clearance in precision bearings is measured in ten thousandths of an inch. Most dirt particles are larger than one thousandth of an inch, so hard particles will indent the race and ball surfaces when the bearing rotates.



ABRASIVE WASTE MATERIALS

In many machinery applications—farm implements, industrial grinders, wood working tools and many others—there may be an abrasive waste product which infringes upon the efficient operation of bearings. This would also apply where coolants, washing solutions, acids, or other liquids are used around a bearing application.

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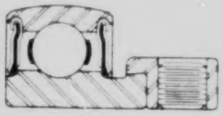
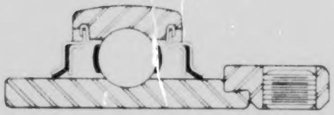
3. PREVENTIVE MEASURES

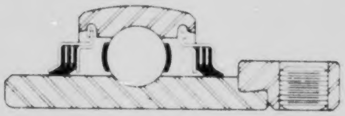
AVOID DAMAGE FROM ABRASIVE WASTE PRODUCT



PLYA SEAL



"R" SEAL



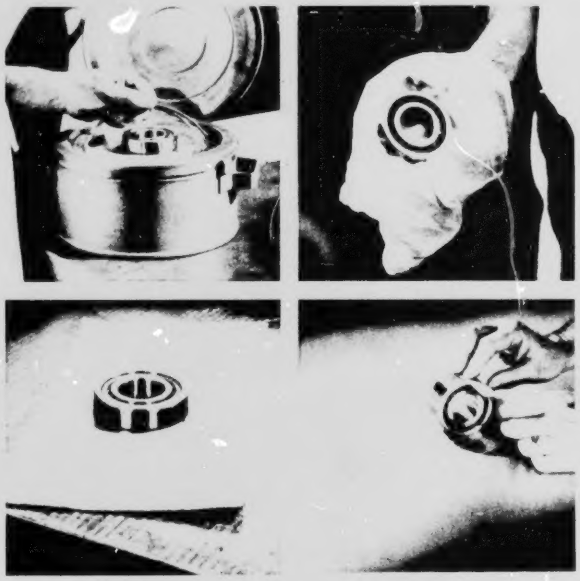
TRI-PLY SEAL

Where a manufacturing process involves an abrasive by-product, it is essential that the bearing be properly sealed. Where failures of this kind prevail, a more efficient seal is required. In applications where extreme contamination is encountered, a sealed housing or shroud may be incorporated to protect the bearing.

CLEAN WORKING SURROUNDINGS

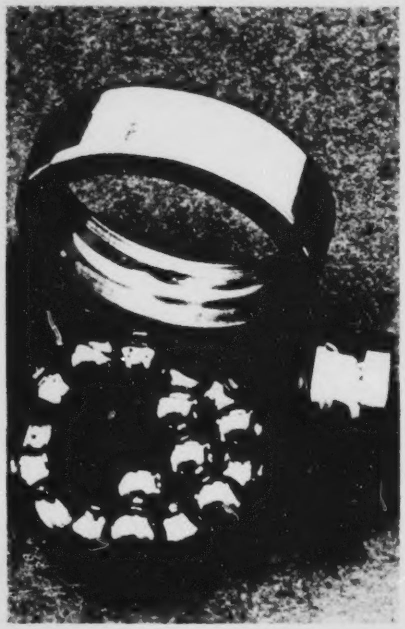
Clean tools, dirt-free working area, and clean dry hands are essential to prevention of bearing failures. Careful control of washing procedures, relubrication, and handling of bearings according to recommended practices will alleviate many of the problems of contamination failures. The following is a list of procedures outlined by the Anti-Friction Bearing Manufacturers Association for the control of cleanliness in the handling of bearings:

1. *Work with clean tools in clean surroundings.*
2. *Remove all outside dirt from housing before exposing bearings.*
3. *Handle with clean, dry hands.*
4. *Treat a used bearing as carefully as a new one.*
5. *Use clean solvents and flushing oils.*
6. *Lay bearings out on clean paper and cover.*
7. *Protect disassembled bearings from dirt and moisture.*
8. *Use clean, lint-free rags if bearings are wiped.*
9. *Keep bearings wrapped in oil-proof paper when not in use.*
10. *Clean inside of housing before replacing bearings.*
11. *Install new bearings as removed from packages.*
12. *Keep bearing lubricants clean when applying and cover containers when not in use.*



BRINELLING

1. IDENTIFICATION



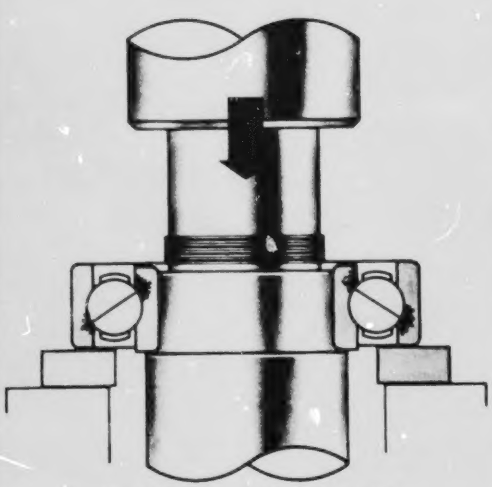
MOUNTING INDENTATIONS
(THRUST FORCE)

This failure will appear as tiny indentations (sometimes barely discernable to the naked eye) high on the shoulder of the race. The dents will be angularly spaced in correspondence to the ball spacing. There will be a corresponding indentation of lesser magnitude on each ball. When the bearing is radially loaded, the brinnels on the race shoulder may not interfere with the ball tracks. In this event, the dent on the ball will cause the failure. In the later stages of failure, spalling or chipping may result. The race shoulders can be inspected (with a microscope if available) to see if a spalling failure may not have resulted from initial brinelling.

RADIAL INDENTATIONS
(RADIAL FORCE)

The indentations have the same general appearance as those mentioned above except that they appear in the center of the race instead of on the shoulder. This type of brinell is less common than the mounting brinell because, under the sharp impact of radial shock load, the rings may fracture beneath the force.

2. CAUSE



INCORRECT ARBOR PRESS DISMOUNTING

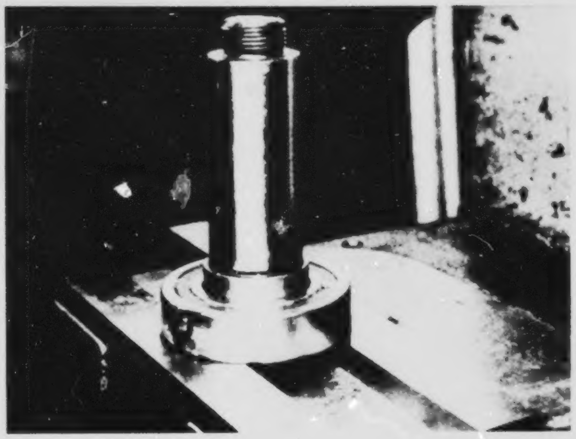
FORCE INCORRECTLY EXERTED

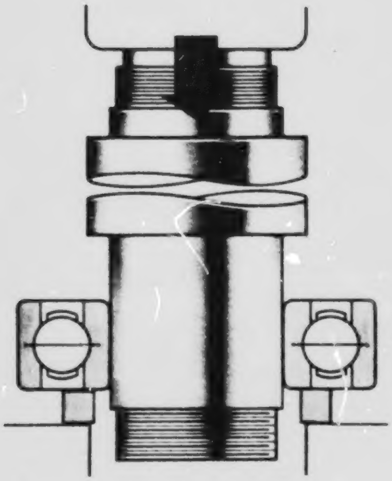
Indentations high on the race shoulder are caused in mounting (or dismounting) where force is applied against the unmounted ring. When mounting a bearing on a shaft with a very close fit, pushing of the outer ring will exert an excessive thrust load bringing the balls into sharp contact with the race shoulder, causing a brinell.

RADIAL SHOCK LOAD

Radial indentations are caused by a shock load imposed radially on a non-rotating bearing. This may be imposed by hitting the bearing with a hammer or by an operating shock load exerted on a static shaft.

3. PREVENTIVE MEASURES



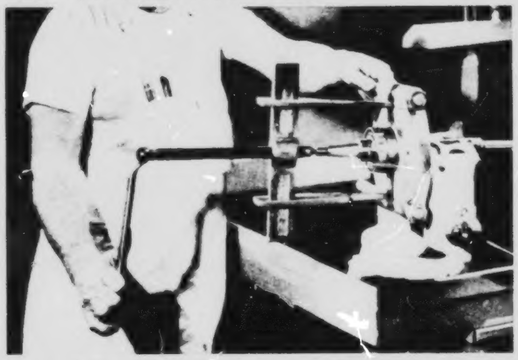


PROPER MOUNTING PROCEDURE

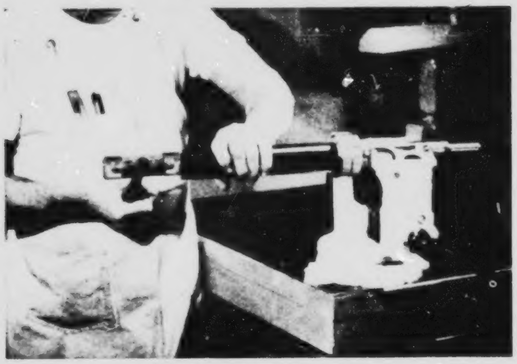
In mounting a bearing, force should always be exerted against the ring being mounted. In other words, when mounting the bearing on a shaft, the pressure should be applied against the inner ring. When mounting in a housing press against the outer ring. In other words the ring having the tighter fit (usually the ring which will rotate in application) should be pushed.

Be sure when mounting a bearing to apply the mounting pressure slowly and evenly.

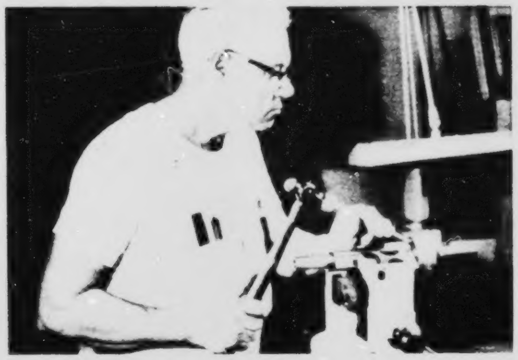
OTHER METHODS OF MOUNTING OR DISMOUNTING



Dismounting with bearing puller and puller jaws.



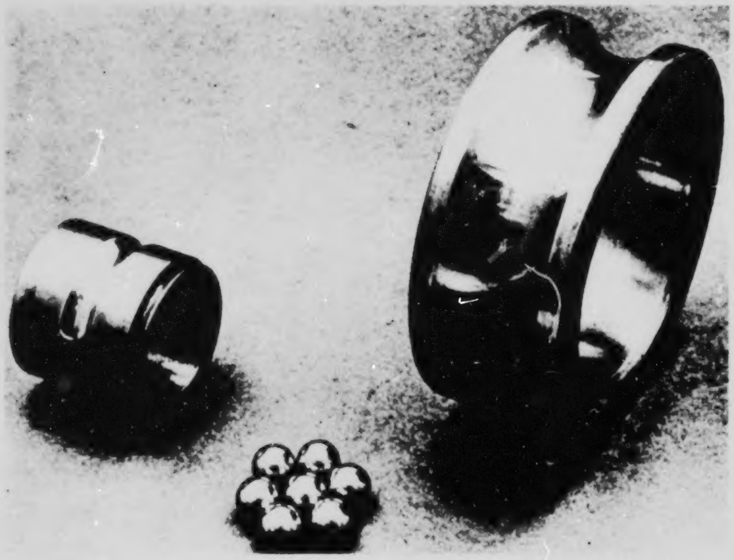
Mounting with tubular drift.



Dismounting with semi-circular drift.

FALSE BRINELLING

1. IDENTIFICATION



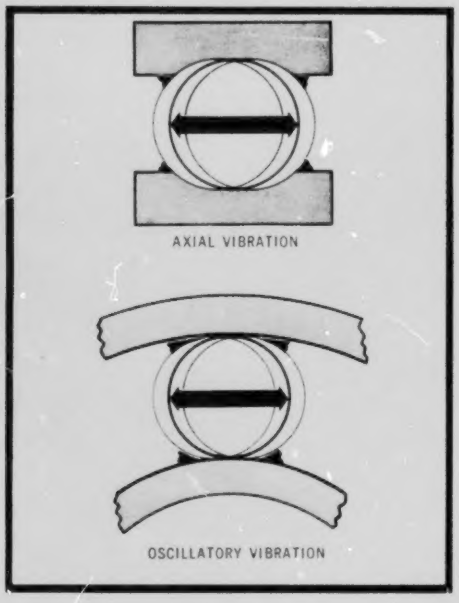
AXIAL INDENTATIONS

This type of brinelling will appear as elliptical impressions which run axially across the races. There will be a build-up of reddish lubricant around each brinell. Also, the brinells will be spaced corresponding with the ball spacing.

CIRCUMFERENTIAL INDENTATIONS

This will appear exactly as the brinell above except that the impression will be wider in a circumferential direction.

2. CAUSE



VIBRATION IN A STATIC BEARING

False brinelling is caused by a vibration of the balls between the races in a stationary bearing. This vibration may be either axial or circumferential. The appearance of the brinells will tell you which. As the ball vibrates between the races, the lubricant is forced out of the contact area between ball and race. The failure is the result of a breakdown of the lubricant causing metal-to-metal contact and localized wear of balls and races. The wearing action causes the formation of a fine reddish brown powder, iron oxide. The oxide impregnates the lubricant and provides an abrasive compound which will polish the balls and races if the bearing is put into operation. The indentations themselves will result in a rough and noisy operation of the bearing. Vibration in a bearing may be caused by a number of factors. Transporting mounted, but unlocked, bearings can result in a false brinell failure. A very common cause of this failure exists where a machine is "down", and the bearings are subjected to static vibration by other machinery which is running in the immediate area.

1056

3. PREVENTIVE MEASURES

CORRECT THE SOURCE OF VIBRATION

The source of agitation—loose parts, non-precision machinery, rough transportation—may be corrected so that vibration is alleviated.

LOCKING THE BEARING

In the transportation of bearings, if a light thrust load (imposed by springs or rubber pads) can be applied to bring all of the balls into contact with the races, this type of failure can be avoided.

ALL SURFACES ADEQUATELY LUBRICATED

Where bearings are oil lubricated and employed in units that may not be in service for extended periods, the equipment should be set in motion periodically in order to spread the lubricant over all bearing surfaces. Intervals of 1 to 3 months should suffice.

TIGHT INTERNAL FIT-UP

Sometimes a bearing with line-to-line contact between rings and balls will alleviate a false brinell failure. Great care should be taken, however, that a tight internal fit is satisfactory from an operation point-of-view.

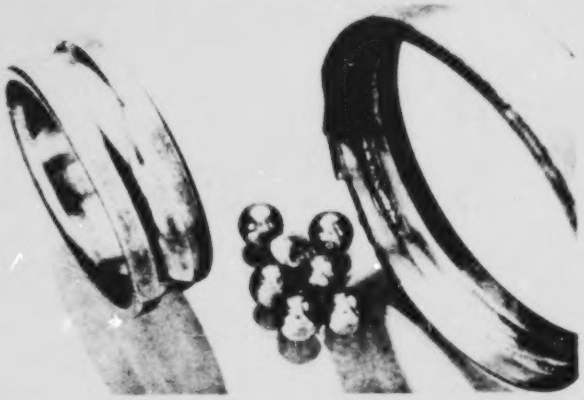
LOW VISCOSITY LUBRICANT

False brinelling is more common with stiffer lubricants. This failure is less apt to occur where oil or a light viscosity grease is used, because the more liquid characteristics make it difficult for the lubrication to be forced out of the contact area.

1057

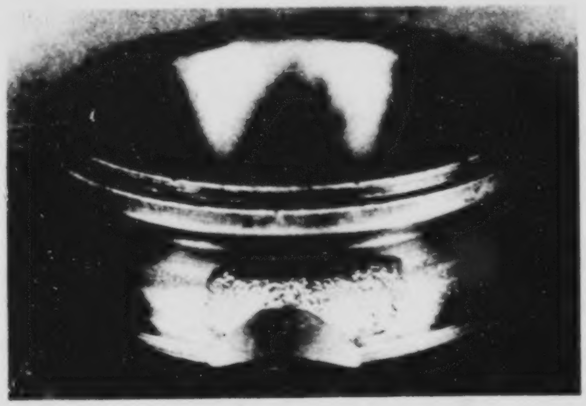
THRUST FAILURES

1. IDENTIFICATION



COUNTERBORED BEARING

There will be a breakdown of the counterbored shoulder of the bearing which may result in fracture of the ring. The balls will be banded from riding up against the shallow shoulder. Also the bearing may become disassembled during service.

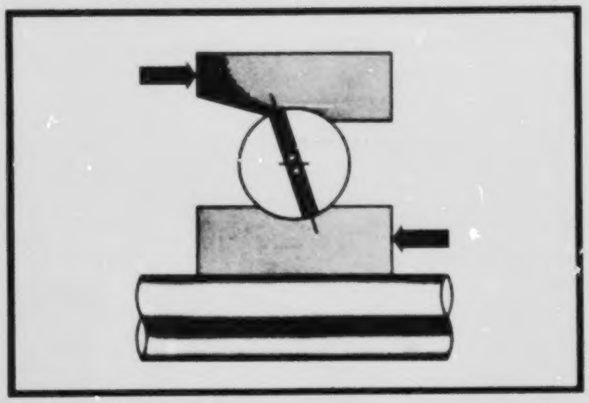


MAXIMUM CAPACITY

Bearings with filling slots are not recommended for heavy thrust loading because, as the balls pass over the inner ring and outer ring notches, they may become nicked or dented. This in turn may cause spalling of the races (probably in the vicinity of the loading slot).

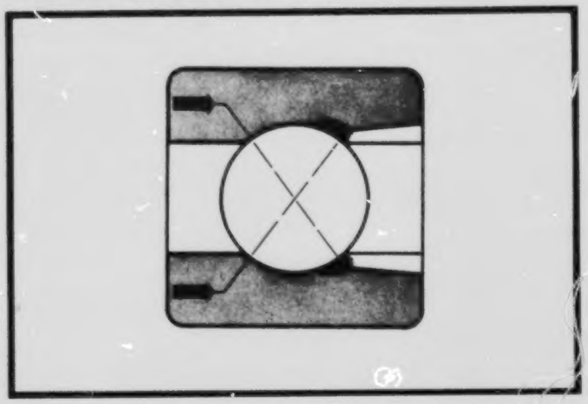
2. CAUSE

IMPROPER MOUNTING OR MISAPPLICATION AS INDICATED:



COUNTERBORE FAILURE

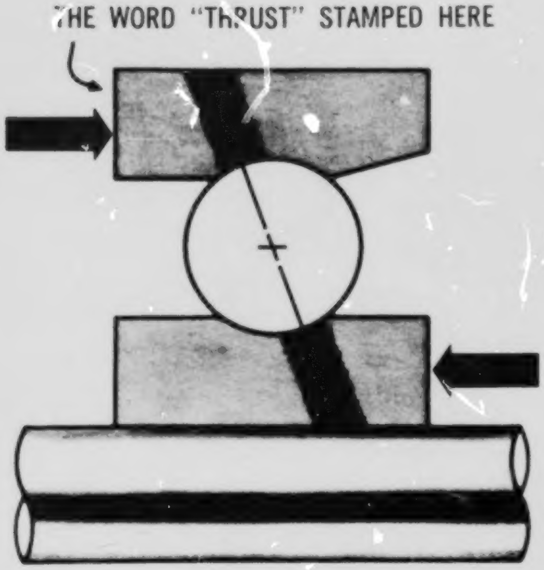
A thrust failure is caused either by mounting the bearing backwards (so that the load is carried against the shallow shoulder) or by putting a counterbored bearing into a two-directional thrust application.



MAXIMUM CAPACITY FAILURE

This failure results from excessive thrust loads on a bearing not primarily intended for heavy thrust loads. From the diagram it is evident that too much thrust load from either direction will cause interference between the balls and one of the loading slots which are ground in both the inner and outer rings.

3. PREVENTIVE MEASURES



COUNTERBORE FAILURE

The remedy here is simply to mount the bearing correctly so that the ball has full-shoulder support on both the inner and outer ring. Remember that the outer ring counterbore bearing will take thrust against the inner ring on the counterbored side of the bearing and the outer ring on the side opposite the counterbore. The word THRUST will be stamped on the outer ring face showing the proper thrust surface.

MAXIMUM CAPACITY FAILURE

This bearing is designed for heavy radial or combined radial-thrust loads; not for pure thrust loading. (It is generally recommended that no more than 60 percent of the accompanying radial load on the bearing be applied in thrust.) If thrust capacity is required, a more suitable bearing (a Conrad type, a counterbored bearing, or possibly a duplexed pair of bearings) must be selected.

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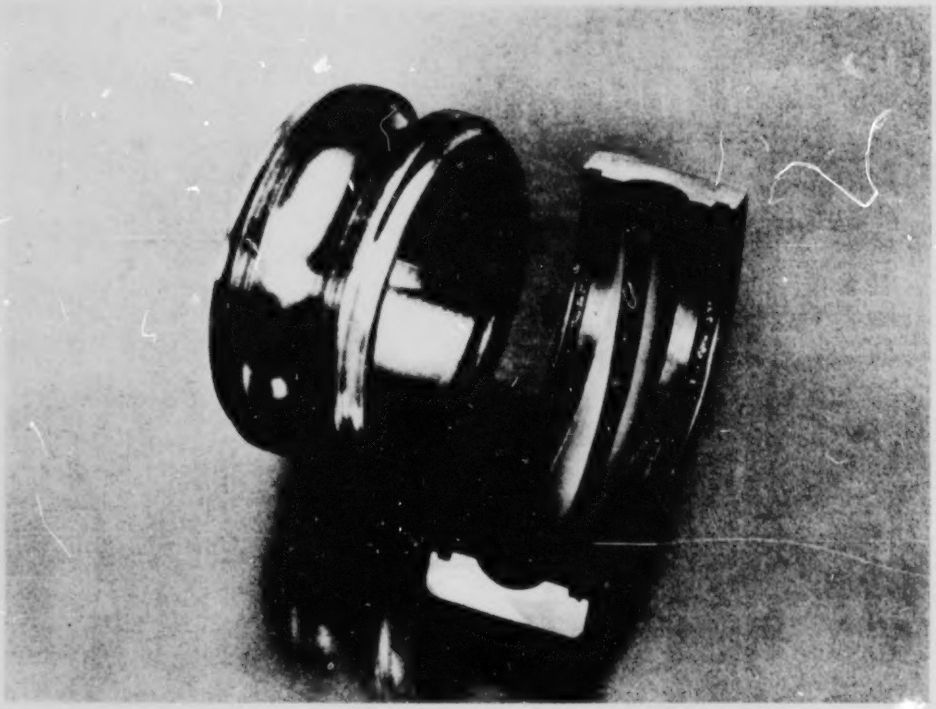
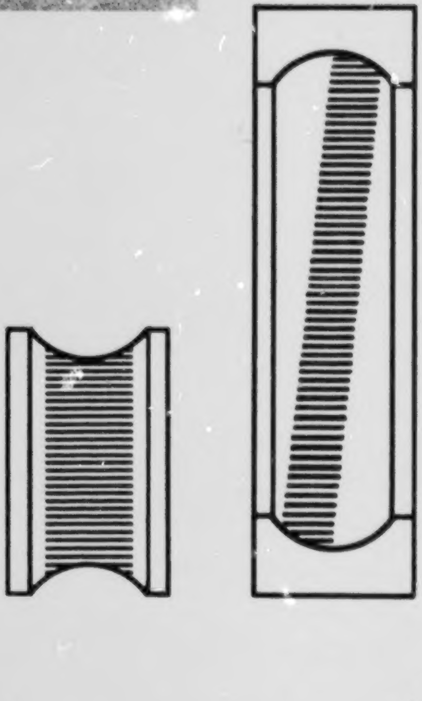
MISALIGNMENT

1. IDENTIFICATION



BALL PATH

In a bearing with one of its rings misaligned in relation to the other, the ball path will run from one side of the race to the other around one half the circumference on the nonrotating ring. The rotating ring will have a wide ball path. Because of the extra pressure imposed on the bearing due to misaligned conditions, an excessively high temperature may develop which will discolor the ball tracks and balls and destroy the lubricant.

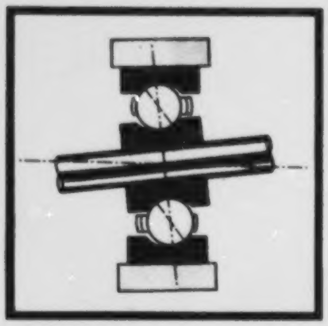


RETAINER

The purpose of the retainer is to space the balls and guide them in a true path around the raceway. Where a ring is misaligned, the balls are driven up against the race shoulder, and a stress point is set up between the ball and its retainer pocket. The pocket will flex with the possibility of retainer fracture in advanced stages of failure.

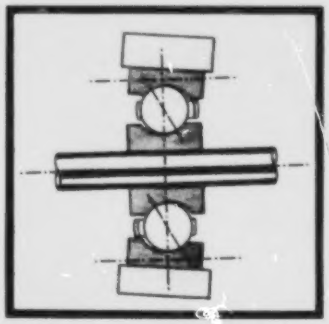
1060

2. CAUSE



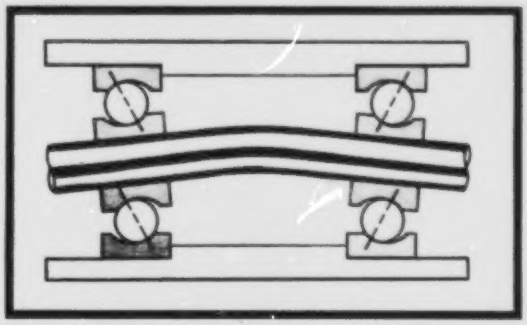
SHAFT MISALIGNMENT

Misalignment of the shaft in relation to the housing causes an overload of the balls which will result in the failure described.



MISALIGNMENT OF THE HOUSING

Housing misalignment may be caused either by the housings being cocked with the plane of the shaft or the housing shoulder being ground out-of-square so that it forces the outer ring to cock in relation to the inner. It may also result from settling of the frames or foundations.

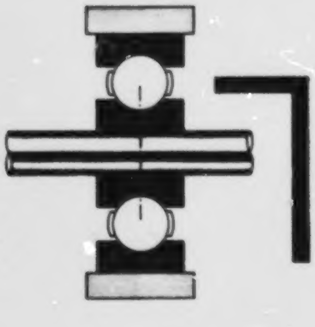


BOWING OF THE SHAFT

Shaft bowing may be caused by any one of the following:

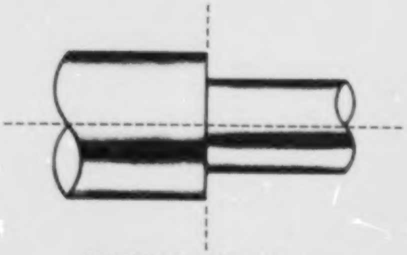
(a) Bent as a result of improper handling
(b) Overhung load exceeding shaft capacity
(c) Initial shaft bowing due to grinding inaccuracies
(d) Shaft shoulders ground out-of-square with the shaft centerline which will, by cocking the inner ring, force a bowing of the shaft.

3. PREVENTIVE MEASURES



SHAFT

The shaft should be gaged to make sure that it is concentric and straight. Heavy overhang loads should be lightened or moved closer to the bearing. If the shoulders are out-of-square, they should be reground and gaged so that they are perpendicular to both the bearing seat and the shaft centerline.



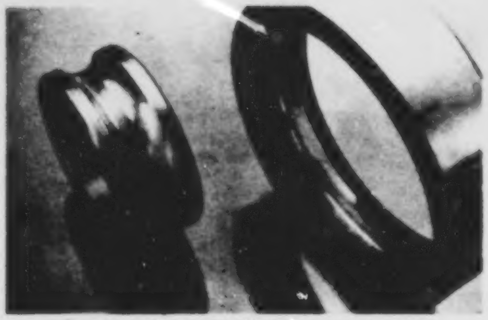
SQUARING-UP SHAFT SHOULDERS

HOUSING

The remedy is to dimensionally check and insure that both housing bores are true with each other.

ELECTRIC ARCING

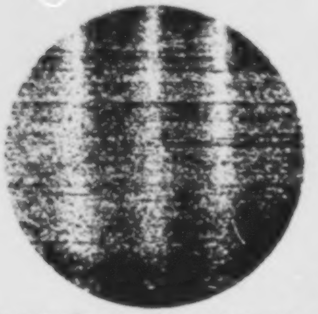
1. IDENTIFICATION



Electro-etching on both inner and outer ring.

ELECTRIC ARC EROSION

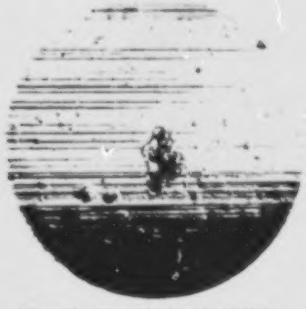
When an electric current passing through a bearing is broken at the contact surfaces between races and balls, arcing results which produces high temperatures at the localized points. Each time the current is broken in its passage between ball and race a pit is produced on both parts. Eventually the phenomenon known as fluting develops, (see photograph) and as it becomes deeper, noise and vibration result.



Magnification of granular race surface.

GRANULAR RACE SURFACES

If the current is of higher amperage intensity, such as a partial short circuit, the next phase of the failure will show up as a rough granular appearance in the ball track.

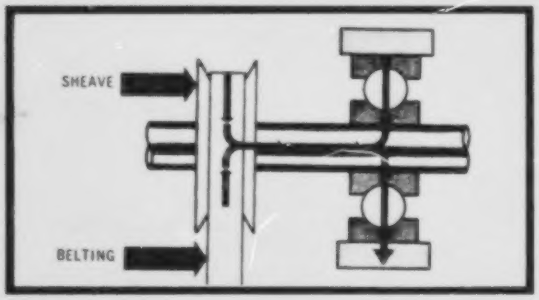


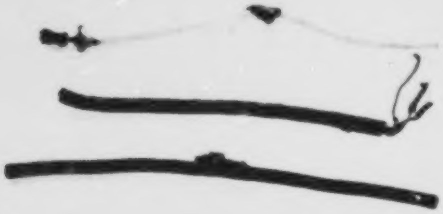
Magnification of electric pitting.

PITTING OR CRATERING

Heavy jolts of high amperage charges will cause a more severe failure resulting in the welding of metal from the race to the ball. These nipples of metal on the ball will, in turn, cause a cratering effect in the race. This phenomenon will result in noise and vibration in the bearing.

2. CAUSE





STATIC ELECTRICITY

Static electricity usually emanates from charged belts or from manufacturing processes using calendar rolls (leather, rubber, cloth, paper).

The current is carried from the belt to the pulley or sheave; from the sheave to the shaft; and through the shaft to the bearing and thence to the ground.

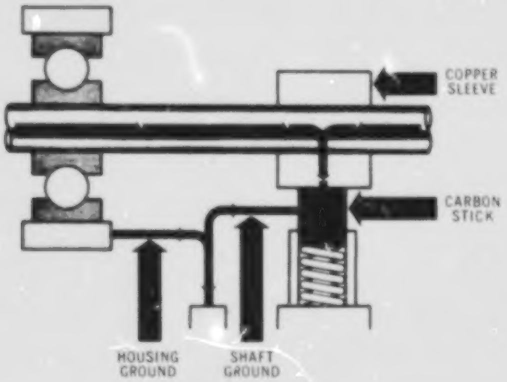
ELECTRIC LEAKAGE

Faulty wiring, inadequate or defective insulation, or loose rotor windings on an electric motor are all possible sources of current leakage. Either AC or DC currents will damage bearings.

SHORT CIRCUIT

Wires which are crossed or contacted by a common conductor will cause a short circuit and may result in a passage of current through the bearing.

3. PREVENTIVE MEASURES

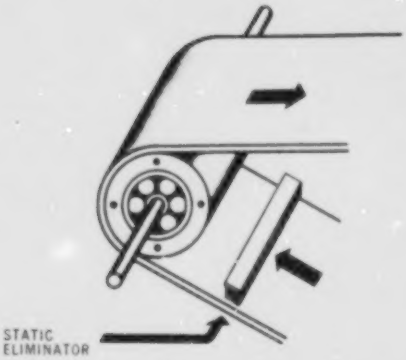


SHUNTS AND SLIP RINGS

Where there is a passage of current through a bearing and the source of the current cannot be corrected, a shunt in the form of slip ring assembly may be incorporated to by-pass the current around the bearing.

CORRECTIVE MAINTENANCE

Be sure wiring, insulation, or rotor windings are sound and all connections are properly made. In arc welding, great care should be taken that the welding apparatus is not grounded on something which will circulate the current through the bearings.



GROUNDING BELTS

For elimination of static charges, either the belt should be grounded, or the belting should be changed to a less generative material.

INSULATING BEARINGS

Sleeves of nonconductive material may be used either between the outer ring and housing or between inner ring and shaft, depending upon the source of current.

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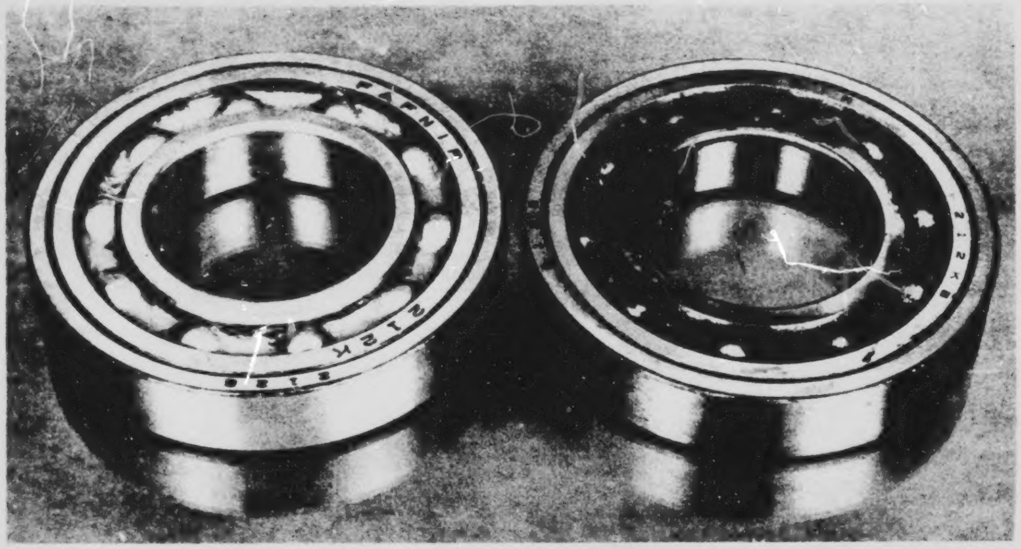
LUBRICATION FAILURE

1. IDENTIFICATION



New bearing with fresh grease on the left as contrasted with lubrication breakdown on the right.

GREASE APPEARANCE

If the grease is stiff or caked and changed in color, it indicates lubrication failure. The original color will usually turn to a dark shade or to jet black (see photo.) The grease will have an odor of burnt petroleum oil. Lubricity will be lost as a result of lack of oil. In cases of Lithium base greases the residue appears like a glossy brittle varnish which will shatter when probed with a sharp instrument.

ABNORMAL TEMPERATURE RISE

Probably the first indication of lubricant failure is a rapid rise from the normal operating temperature. Test by hand is not necessarily conclusive since normal operating temperature may exceed the bearable limit of about 120° F.

NOISE

Lack of lubrication is soon accompanied by a whistling noise coupled with this rise in temperature. If not corrected the bearing temperature will continue to rise and the intense heating will reduce the bearing hardness.

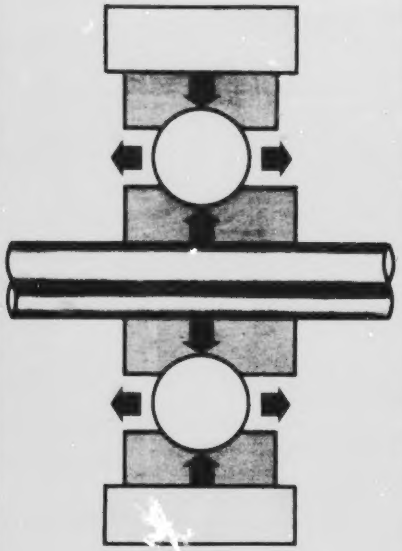
BEARING DISCOLORATION

A brownish or bluish discoloration of the races and balls indicates that the bearing operating temperature was excessively high to the extent that the bearing lost its physical properties and was no longer operable.

RETAINER FAILURE

The bearing part that first indicates distress in lubrication failures is usually the retainer where the greatest amount of rubbing action takes place.

2. CAUSE



Lubrication failures are usually accompanied by a thermal expansion of the components

DIRTY LUBRICATION

The Fafnir Bearing Company filters ball bearing lubricants as many as five times to insure their purity. Contaminants found in lubricants often act as an abrasive compound which will lap or polish ball and race surfaces, increasing the probability of early failure.

TOO MUCH LUBRICANT

A very common error in the maintenance of machinery is the tendency to over-lubricate. If the bearing reservoir is kept constantly full of grease, the friction heat developed within the lubricant will cause its rapid deterioration.

INADEQUATE LUBRICATION

Heat will result from under-lubrication, also. Where there is inadequate lubricant to cover all metal surfaces, friction will result in heat-up of the bearing.

WRONG KIND OF LUBRICANT

After experimentation with many types of lubricants, the equipment manufacturer recommends those which he feels will provide ideal lubrication life under given operation conditions. Inasfar as availability allows, you should use the same lubricant or its equivalent. This way you are assured of the correct lubricant in addition to avoiding the problems associated with mixing two types of grease. (Many greases are incompatible and, although completely adequate when used individually, may prove unsatisfactory when mixed.) Selection of the correct lubricant, therefore, is very important in achieving maximum efficiency and endurance from the application.

OTHER FAILURE MODES

In many instances lubricant failure will accompany the bearing failures described in this manual. The primary cause of lubricant failure is from the high temperatures developed when excessive loads exceed the strength of the lubricant film. Lubricant changes might reduce the failure rate but the proper course of action is to eliminate the primary cause for the lubricant breakdown.

3. PREVENTIVE MEASURES

AVOIDING DIRTY LUBRICANT

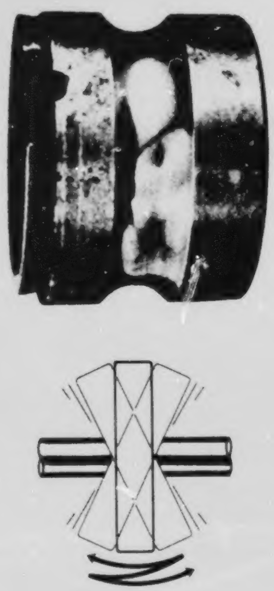
Always keep grease containers covered. Dust particles in the air can contaminate the lubricant. Use a clean rust-resistant spatula for relubricating open bearings. When relubricating bearings through a grease fitting, always wipe off both the fitting and the nozzle of the grease gun. Any steps which you can take to keep lubricants clean will pay off in longer bearing life.

AMOUNT OF LUBRICANT

When you are unsure of the amount of grease or oil for proper lubrication, the Fafnir engineering department should be consulted. In standard applications, it is generally recommended that the bearing should be greased one third to one half full.

CAM FAILURE

1. IDENTIFICATION



BROKEN CAM

The eccentric cam on the wide inner ring bearing will have a wedge-shaped fracture in it. Depending upon the degree of failure the fracture may extend into the cam or all the way into the race of the bearing.

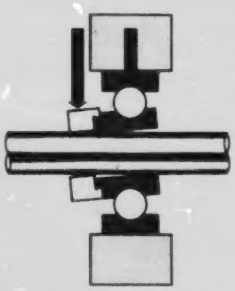
BALL PATH

Because the inner ring will be cocked on the shaft, the ball path will have a wobbly appearance similar to that on a misaligned bearing. The ball path will run from one side of the non-rotating ring to the other for one half of the perimeter of the race.

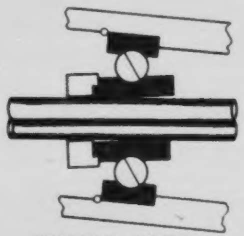
WOBBLE OF BEARING

While in application, the rotating bearing will wobble from side to side. If the housing is flexible enough, the whole assembly may flex with the rotation of the bearing.

2. CAUSE



SHAFTING BELOW SUGGESTED TOLERANCE LEVELS



MISALIGNED OUTER RING

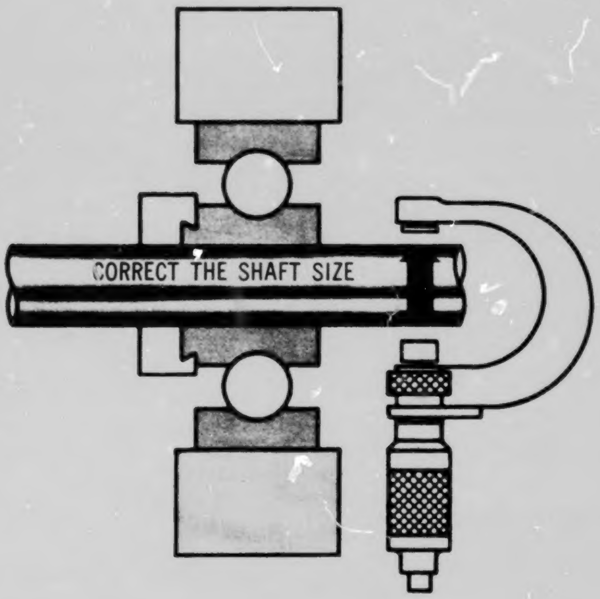
UNDERSIZED SHAFTING

The eccentric cam locking collar was originally developed to provide a means of securing a bearing to low cost cold-rolled shafting. It must not be assumed, however, that the bore-to-shaft fit is without some tolerance control. Fafnir has set up tolerance limits (see Preventative Measures for recommended limits) for shaft fits on wide inner ring bearings, which must be maintained if this type of failure is to be avoided. When the eccentric collar is locked to its inner ring mating cam on an undersized shaft, the inner ring becomes cocked on the shaft. (Remember that, for proper locking action, the collar should always be turned in the direction of shaft rotation.) When the machinery is turned on, the inner ring tries to realign itself with the shaft as it rotates. This provides a levering action with a stress area where the collar grasps the inner ring. Eventually this stress will fracture the inner ring cam.

OUTER RING UNABLE TO ALIGN

The same problem exists where an outer ring with a self-aligning feature is clamped so firmly into the housing, that it cannot take advantage of its self-aligning feature. This may happen where the bearing is forced with an excessively tight fit into a cast housing or where pressed steel housing halves are bolted together before the bearing has assumed its initial alignment.

3. PREVENTIVE MEASURES



CORRECT THE SHAFT SIZE

Where a failure occurs, the shaft should be checked with a micrometer caliper to determine how much under normal tolerance the shaft diameter falls. Then, either a new shaft should be obtained or the old one should be plated and ground to correct size.

The following are the recommended tolerances for shafting:

BEARING BORE	SHAFT TOLERANCES
½" to 2"	.0000 to –.0005
2 1/16" to 3 15/16"	.0000 to –.001
4" and over	Because of heavy loading, engineering department should be consulted.

ALLOWING THE BEARING TO ALIGN

Fafnir has incorporated a self-aligning feature—a spherical outer ring—into its wide inner ring line to compensate for a certain amount of initial misalignment. The proper mounting procedure is to: (1) Align the bearing in its housing and slide unit into position on the shaft (2) bolt the housing tightly to its mounting support (3) engage and tighten locking collar and set screw.

QUESTIONS

8.37A What are the different types of bearings used in pumps?

8.37B What should be done whenever a bearing failure occurs before its expected replacement time?

8.37C List as many different types of bearing failures as you can remember.

8.37D What can cause contamination failure of a bearing and how can it be prevented?

8.37E How can bearing failures from misalignment be prevented?

8.37F How can bearing lubrication failures be identified?

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8.38 Couplings

8.381 Purpose of Couplings

Pumps must be driven by some means in order to operate. Electric motors, gasoline or diesel engines, air pressure, hydraulic pressure, steam pressure, and other sources of power are used to drive pumps. Electric motors and gasoline or diesel engines are the most common source of power used in the wastewater field. In order to connect these drivers to the pump, a coupling is needed (Fig. 8.27). There are several ways to couple a pump and driver together. Some of the most common methods are:

1. Direct Coupled
2. Belt Driven
3. Flexible Shafting
4. Close-coupled.

Each method has its advantages and limitations and is used for a specific purpose.

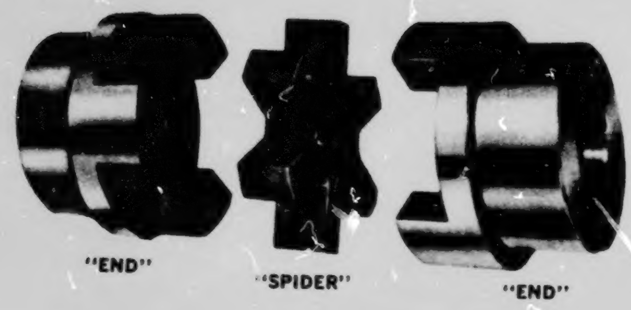
8.382 Direct Coupled

Pumps and drivers are directly coupled when they are mounted on a common base, and the speed of the driver is the same as that of the pump. The shaft of the pump has one of the coupling ends, and the driver has the other end mounted on it. The coupling may be either rigid (clamp and compression) or flexible. A flexible coupling is a device to connect two shafts together, transmit torque, and at the same time allow for very slight misalignments. The main functions of all flexible couplings are:

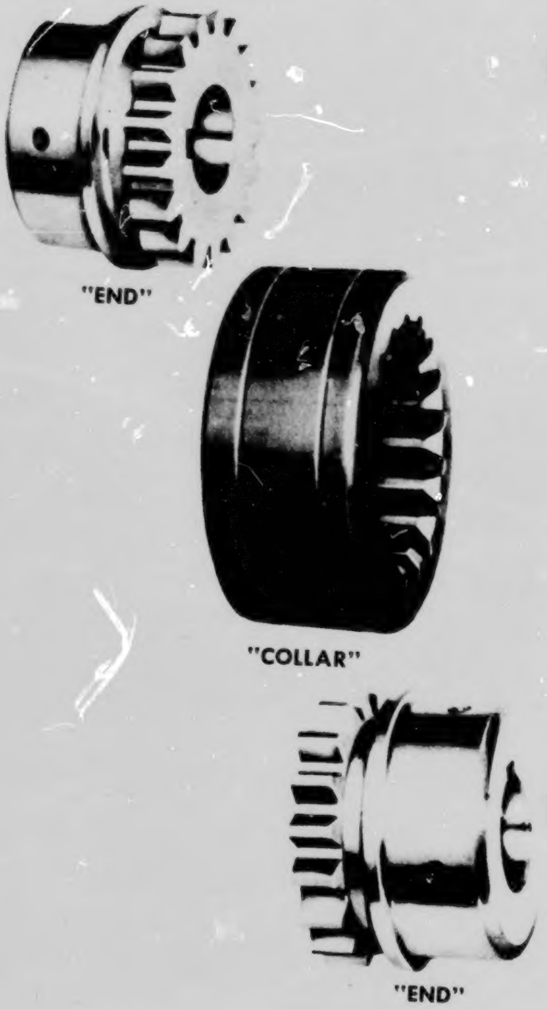
1. To transmit power efficiently and effectively from one shaft to the other.

2. To decrease wear on shaft bearings and driven equipment.

3. To accomodate the slight shaft misalignments which develop in service.


"END"
"SPIDER"
"END"

Flexible Saw


"END"
"COLLAR"
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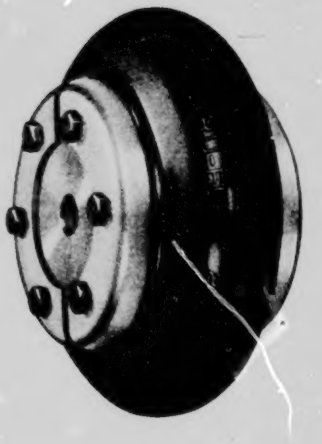
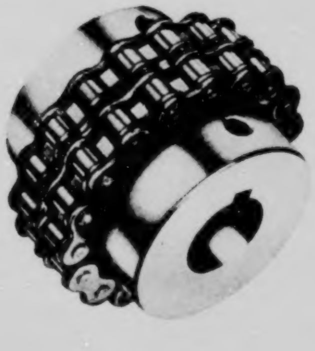
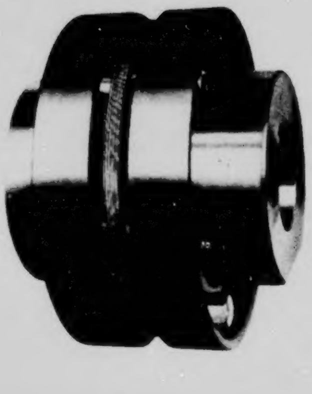
Gear



Tra-Flex



Chain



Disc

Fig. 8.27. Couplings

(Courtesy of Rexnord Inc., Milwaukee, Wisconsin)

Other functions of flexible couplings include:

1. To absorb shock loads and pulsations.
2. To dampen vibrations.
3. To accomodate load reversals.
4. To minimize initial backlash.
5. To provide ease of installation and maintenance.

Alignment (Fig. 8.28)

When shafts are directly coupled, shaft alignment is extremely important. There are two types of shaft alignment:

1. Parallel
2. Angular.

The coupling also can have end float; that is, the shaft moves in and out. This has to be taken into consideration when installing a coupling. Misaligned shafts not properly coupled are subject to severe stresses and damage at bearings and seals.

With couplings that are properly machined, accurate alignment is achieved when the coupling faces are absolutely parallel as measured by feelers --- a straight edge placed squarely across the rings of the coupling halves. Place the feelers at the top, bottom, near and far sides of the coupling junctions. Also place the feelers along the edge of the top and sides of the shaft. Proper alignment is accomplished by the use of wedges and shims[7] under the pump or motor.

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[7] Shim. Thin metal sheets which are inserted between two surfaces to align or space surfaces correctly. Can be used anyplace where a spacer is needed. Usually shims are 0.001 to 0.020 inches thick.

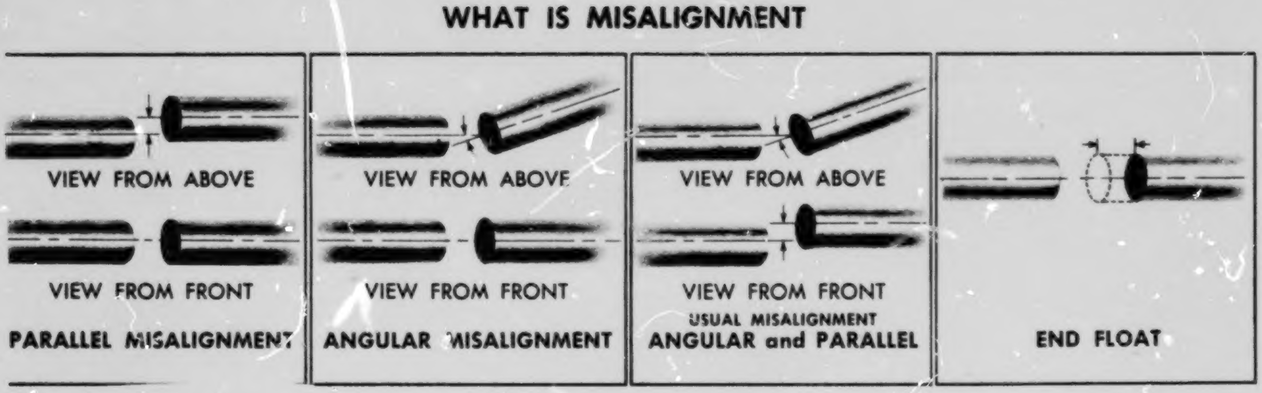

WHAT IS MISALIGNMENT
VIEW FROM ABOVE
VIEW FROM FRONT
PARALLEL MISALIGNMENT
VIEW FROM ABOVE
VIEW FROM FRONT
ANGULAR MISALIGNMENT
VIEW FROM ABOVE
VIEW FROM FRONT
USUAL MISALIGNMENT
ANGULAR and PARALLEL
END FLOAT

Fig. 8.28. What is misalignment?
(Courtesy of Rexnord Inc., Milwaukee, Wisconsin)

When installing a coupling, inspect it carefully. Should there be any misalignment, adjustment is made by installing wedges or shims until no variation is seen by the straight edge or feeler gauge. Hold the pump half coupling stationary and rotate the driver 90 degrees at a time and examine the alignment. Insert shims as necessary to bring shaft into alignment. Make sure both couplings are the same diameter and are clean. The clearance between faces of coupling halves should be set so they cannot strike, rub, or exert a pull on either machine.

Different types of couplings have different tolerances for alignment. Usually tolerances range from .002 inches to .005 inches. Consult with the particular coupling manufacturer for the exact alignment needed. There are so many factors entering into the probable life of a coupling that it is impossible to predict the impact of misalignment on coupling life for every application. Any coupling which is stressed heavily with torque will have very little reserve left for misalignment conditions. On the other hand, if a coupling is lightly torqued, it would have a larger reserve left for misalignment. Also, a coupling traveling at a slow speed, such as used on the slow side of a gear reducer, can take relatively large misalignments over a long period of time. If a coupling is rotating at high speeds, it must be aligned with great care to provide maximum trouble-free service.

QUESTIONS

8.38A What is the purpose of a coupling?

8.38B List four common methods of coupling a pump and driver together.

8.38C What are the functions of a flexible coupling?

8.38D How can you tell if coupling alignment is proper?

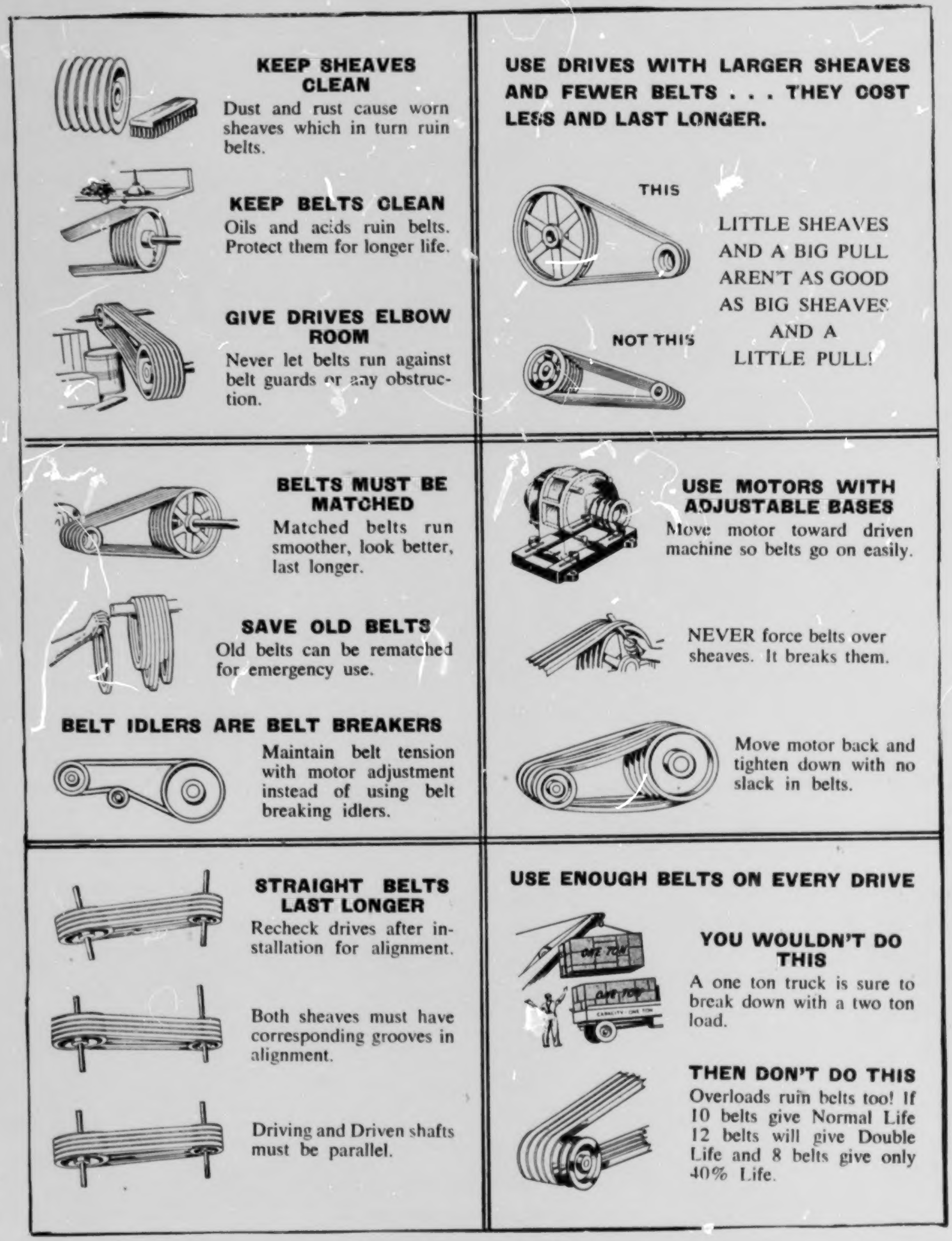
8.38E What do you look for when inspecting clearances between faces of coupling halves?

8.383 Belt Driven

Another method of connecting a pump to a motor or driver is with belts (Fig. 8.29). A pulley is mounted on the pump shaft and another pulley is mounted on the driver. One or more belts are installed connecting the two pulleys together.

The driver can be located above the pump or beside the pump in many different configurations. The pump shaft and motor shaft must be positioned so the pulleys can be aligned with the belts in a straight line. An advantage of driving a pump with belts is the speed ratios that can be achieved between the motor and pump; almost any speed is available. If this speed needs to be changed for any reason, it is only necessary to change a pulley.

V-belt drive pulleys are more commonly known as sheaves. Sheaves are normally made of cast iron or steel and machined to size. They can be single groove, two groove, three groove, or many more depending upon horsepower requirements. The grooves can be for A, B, C, D, or E belts. The letter designation is the cross section of the belt to be used; "A" being the smallest and "E" the largest. A and B belts are most commonly used.



KEEP SHEAVES CLEAN

Dust and rust cause worn sheaves which in turn ruin belts.

KEEP BELTS CLEAN

Oils and acids ruin belts. Protect them for longer life.

GIVE DRIVES ELBOW ROOM

Never let belts run against belt guards or any obstruction.

USE DRIVES WITH LARGER SHEAVES AND FEWER BELTS . . . THEY COST LESS AND LAST LONGER.

THIS

NOT THIS

LITTLE SHEAVES
AND A BIG PULL
AREN'T AS GOOD
AS BIG SHEAVES
AND A
LITTLE PULL!

BELTS MUST BE MATCHED

Matched belts run smoother, look better, last longer.

SAVE OLD BELTS

Old belts can be rematched for emergency use.

BELT IDLERS ARE BELT BREAKERS

Maintain belt tension with motor adjustment instead of using belt breaking idlers.

USE MOTORS WITH ADJUSTABLE BASES

Move motor toward driven machine so belts go on easily.

NEVER force belts over sheaves. It breaks them.

Move motor back and tighten down with no slack in belts.

STRAIGHT BELTS LAST LONGER

Recheck drives after installation for alignment.

Both sheaves must have corresponding grooves in alignment.

Driving and Driven shafts must be parallel.

USE ENOUGH BELTS ON EVERY DRIVE

YOU WOULDN'T DO THIS

A one ton truck is sure to break down with a two ton load.

THEN DON'T DO THIS

Overloads ruin belts too! If 10 belts give Normal Life 12 belts will give Double Life and 8 belts give only 40% Life.

Fig. 8.29. Use of belts.

(Courtesy of Browning)

There are many manufacturers of V belts and it is impossible to list each type and manufacturer available. There are standard belts, super belts, torque-flex belts, band belts, and many others. The best way to select belts is to contact your supplier, give the horsepower, speed, equipment driver, type of load, sheave diameters, and shaft diameters. If it is an existing installation, use the belt numbers found on the belt when reordering. If there are more than one belt installed, they must all be replaced at the same time and be a matched set so all belts will wear evenly.

When installing or replacing V belts, the motor and pump sheave must be aligned. This means that the belt must run straight between the two pulleys without any angle. This can be achieved by placing a straight edge between the two pulleys and making sure that both are on the same plane. Another method is to use a string pulled across both pulleys, making sure that the string hits the pulleys at all points. The belts must be placed over the sheaves and in the grooves without forcing them over the sides of the grooves which would damage the belts.

With all belts in their proper grooves, adjust the centers to take up all slack until the belts are fairly taut. Start the drive and continue to adjust until the belts have only a slight bow on the slack side of the belt drive while operating under load. To determine proper adjustment of belts when the unit is not operating, turn power to unit off, tag and lock out. Adjust belt until there is 3/4-inch of belt movement from hand pressure at the middle of the back belt (Fig. 8.30).

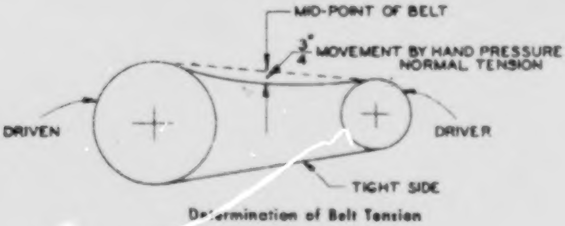

MID-POINT OF BELT
3/4" MOVEMENT BY HAND PRESSURE NORMAL TENSION
DRIVEN
DRIVER
TIGHT SIDE
Determination of Belt Tension

Fig. 8.30. Determination of belt tension.
(Courtesy of Browning)

After a few days of operation, the belts will seat themselves in the sheave grooves. Readjust the belts so that the belt drive again shows a slight bow in the slack side.

The belt drive is now properly tensioned and only occasional re-adjustment for groove wear will be necessary. If belts squeal during start up, reposition motor adjustment to increase tension until slippage and squeal disappears.

If belts are adjusted too tightly, problems can result such as bearing heating and belts wearing excessively.

QUESTIONS

8.38F What is an advantage of driving a pump with belts?

8.38G Why must all belts on a pump be replaced at the same time?

8.38H Why should belts and sheaves be kept clean?

8.38I How can you determine if motor and pump sheave are properly aligned?

8.38J How can you determine if a belt has the proper tightness or tension?

8.38K What should you do when belts squeal during start up?

8.38L What happens when belts are adjusted too tight?

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8.384 Flexible Shafting

Flexible shafting is used where the pump and driver are located relatively far apart (Fig. 8.31). Flexible shafting is particularly suited to transmit power into areas where moisture, dust, corrosive or explosive conditions, or flooding would adversely affect the driving machinery.

Pumping installations with flexible shafting usually have a vertical shaft with the motor located on the floor above the pump. There can be one, two, three, or even more sections of shafting, depending upon the distance between the pump and motor. If there is more than one section of shafting, there will be steady bearing supports.

Shafting is usually trouble-free if installed and lubricated properly. The universal joints (Fig. 8.31) are very similar to those used in your automobile. Universal joints are used to take up any misalignment between pump and driver. The driver and pump need not line up axially, but they must be parallel to one another within plus or minus one degree. Shafts can be offset slightly, but the offset is not necessary. Some manufacturers require and specify a definite offset in some installations. The yokes in the shafting must be in line; that is, the driver and driven yoke must be on the same plane so the two center yokes will be in line.

Lubrication of the universal joints is very important. These should be lubricated every 500 hours of intermittent service, and every 200 hours of continuous service. The particular manufacturer's literature will give the type of lubricant to be used.

Never disassemble the needle bearings from their yokes unless it is necessary to replace the cross and bearing set. To inspect, remove the shaft and test bearings by moving the yoke in all directions to roll the needles. If the action of all four bearings is smooth, replacement is not necessary. If the action is rough or uneven, replace the entire universal joint. A visual inspection will usually tell if one bearing is bad by the appearance of a brown powder in that area. When greasing, if grease does not come out all four bearings, you can usually be assured of a bearing failure.

To replace bearings, have a skilled worker do this job. Tap one end of bearing lightly to remove pressure on the snap ring. Remove the snap ring, and repeat procedure for the opposite bearing. Then with

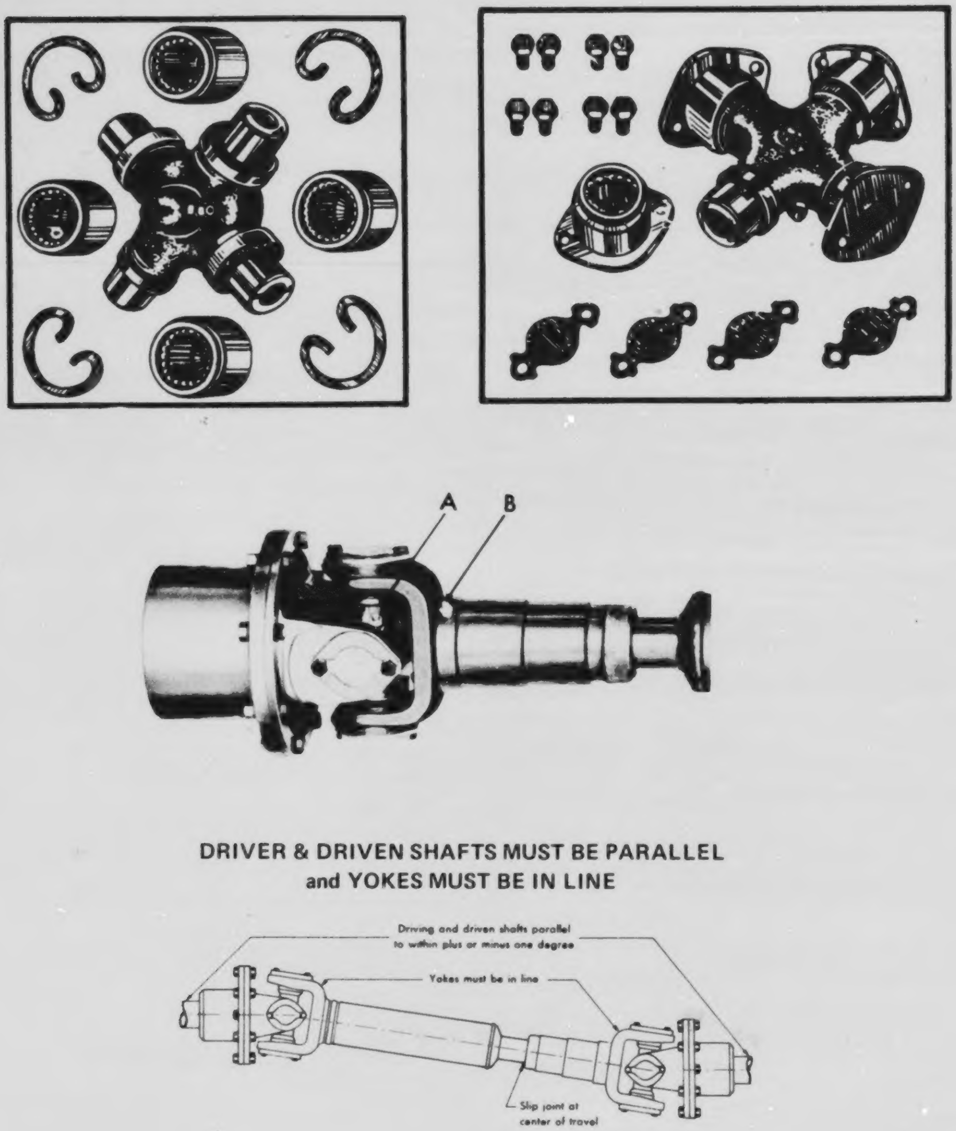
A
B
DRIVER & DRIVEN SHAFTS MUST BE PARALLEL
and YOKES MUST BE IN LINE
Driving and driven shafts parallel to within plus or minus one degree
Yokes must be in line
Slip joint at center of travel

Fig. 8.31. Flexible shafting and universal joints. (Courtesy of H. S. Watson Company)

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a soft drift, drive on one bearing to push the opposite bearing out of its yoke. Remove exposed bearing and reverse joint and drive on the exposed cross to push out the other bearing. Repeat procedure on other two bearings.

To assemble, remove bearings from the new cross assembly, holding the cups so the needles do not fall out. Position the cross in one yoke. Position one bearing cup with its needles in the yoke and insert the journal of the cross into this bearing. Press bearing into yoke. Repeat for opposite bearing. If press is not available, use a vise. Never hammer new bearings. Install snap rings, and repeat for other two bearings.

QUESTIONS

8.38M Where is flexible shafting installed?

8.38N How often should universal joints be lubricated?

8.38O How can you tell if there is a bearing failure in a universal joint?

END OF
LESSON
3 OF 4
LESSONS
ON
EQUIPMENT MAINTENANCE

DISCUSSION AND REVIEW QUESTIONS

Chapter 8. Equipment Maintenance
(Lesson 3 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

13. How would you inspect a pump impeller?

14. What factors can cause cavitation of a pump impeller?

15. How would you inspect a pump shaft?

16. How would you repack a pump?

17. What are the advantages and limitations of mechanical seals?

18. What are some causes of bearing failures?

19. How are pumps and drivers connected together?

HOW?
WHAT?
WHEN?
WHERE?
WHO?

CHAPTER 8. EQUIPMENT MAINTENANCE

(Lesson 4 of 4 Lessons)

8.4 COMPRESSORS

Compressors (Fig. 8.32) are used in connection with operation and maintenance work throughout the wastewater collection system. They are used with wastewater ejectors, pump control systems (bubblers), valve operators, and water pressure systems. Also they are used to operate portable pneumatic tools, such as, jack hammers, compactors, air drills, sand blasters, tapping machines, and air pumps.

A compressor is a device used to increase the pressure of air or gas. They can be of a very simple diaphragm or bellows type such as are found in aquarium pumps, or extremely complex rotary, piston, or sliding vane type compressors. A compressor usually has a suction pipe with a filter and a discharge pipe which goes to an air receiver or storage tank. The compressed air or gas is then used from the air receiver.

Due to the complexity of compressors, the wastewater maintenance worker usually will not be repairing them. You will, however, be required to maintain these compressors. With proper maintenance a compressor should give years of trouble-free service.

The first step for compressor maintenance, and this pertains to any mechanical equipment, is to get the manufacturer's instruction book and read it completely. Each compressor is different and the particular manufacturer will list their recommended maintenance schedules and procedures. Some of the maintenance procedures are:

MFG'RS
INSTRUCTION
BOOKS

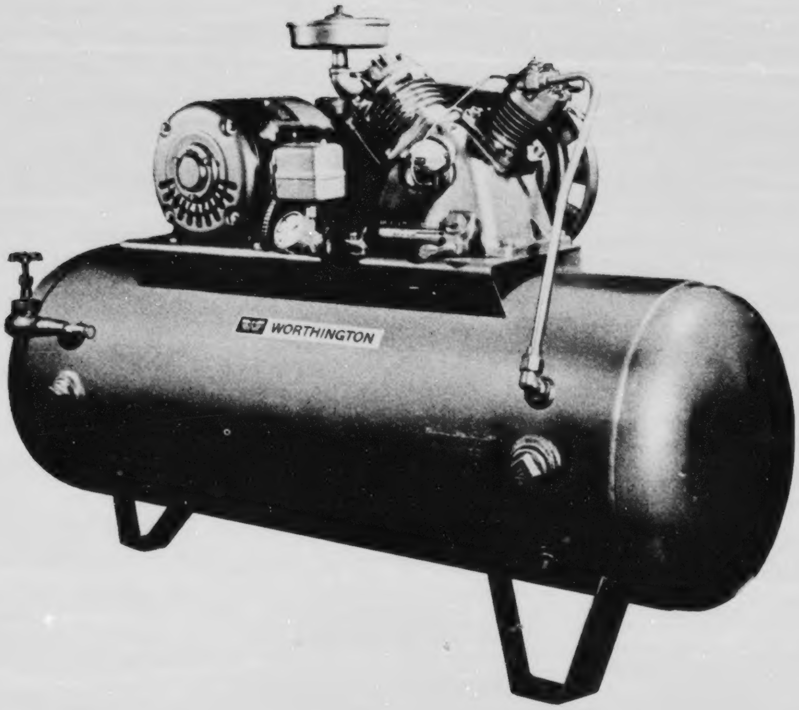
WORTHINGTON

Fig. 8.32. Two-stage piston compressor.
(Courtesy Worthington Corporation)

1. Inspect the suction filter of the compressor regularly. The frequency of cleaning depends upon the use of the compressor and the atmosphere around it. Under normal operations the filter should be inspected at least monthly and cleaned or replaced every three to six months. Inspect and replace the filter more frequently in areas with excavation and dust. When breaking up concrete, inspect the filters daily.

   There are several types of filters, such as, paper, cloth, wire screen, oil bath, and others. The impregnated paper filters must be replaced when dirty. The cloth-type filters can be washed with soap and water, dried and reinstalled. If a cloth-type filter is used, it is recommended that a spare be kept so one can be cleaned while the other is being used. The wire mesh and oil-bath type filters can be cleaned with a standard solvent, reoiled or oil bath filled and used again. Never operate a compressor without the suction filter because dirt and foreign material will collect on the rotors, pistons, or blades and cause excessive wear.

2. Lubrication: Improper or lack of lubrication is probably the biggest cause of compressor failures. Most compressors have oiling of some type for the bearings. They can have crank case reservoirs, oil cups, grease fittings, a pressure system or separate pump. Whatever type, it must be inspected daily. Examine the reservoir dip stick or sight glass. Make sure that drip feed oilers are dripping at the proper rate; force feed oilers have the proper pressure; and grease fittings are greased at the proper interval. Compressors use a certain amount of oil in their operation and special attention is needed to keep the reservoirs full. Care also must be used

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to not overfill the crankcase. On some compressors it is possible for the oil to get into the compression side and lock up the compressor, or damage it. Remember!

A LIQUID CANNOT BE COMPRESSED.

When air or gas are compressed, they give off heat and the compressor becomes very hot. This tends to break down oil faster, so most compressor manufacturers have special oils recommended for their particular compressor. Also, due to the heat and contamination, it is necessary to change oil quite frequently. Compressor oil should be changed at least every three months, unless manufacturer states differently. If there are filters in the oil system, these also should be changed.

3. Cylinder or casing fins should be cleaned weekly with compressed air or vacuumed off. The fins must be clean to insure proper cooling of the compressor.

4. Unloader. Many compressors have unloaders that allow the compressor to start under a no load condition. These can be inspected by observing the compressor. When the compressor starts, it should come up to speed and the unloader will change, starting the compression cycle. This can usually be heard by a change in sound. When it stops, you can hear a small pop and hear the air bleed off the cylinders. If the unloader is not working properly, the compressor will stall when starting, not start, or if belt driven, burn off the belts.

5. Test the safety valves weekly. The pop off or safety valves are located on the air receiver or storage tank. They prevent the pressure from building up above a specified pressure by opening and venting to the atmosphere. In gas compressors, they vent to the suction side of the compressor. Some compressors have high pressure cut-off switches, low oil pressure switches, and high temperature cut-off switches. These switches have pre-set cut off settings and must not be changed without proper authorization. If for any reason any of the safety switches are not functioning properly, the problem must be corrected before starting the compressor again. The safety switch settings should be recorded and the results kept in the equipment file.

6. Drain the condensate (condensed water) from the air receiver daily. Due to temperature changes, the air receiver will fill with condensate. Each day the condensate should be drained from the bottom of the tank. There is usually a small valve at the bottom of the air receiver for this purpose. Some air receivers are equipped with automatic drain valves. These must be inspected periodically to insure they are operating satisfactorily.

7. Inspect belt tension on compressors. Usually you should be able to press the belt down with hand pressure approximately three-fourths of an inch. This is done at the center between the two pulleys. MAKE SURE COMPRESSOR IS LOCKED OFF BEFORE MAKING THIS TEST. Do not over tighten belts because it will cause overheating and excessive wear on bearings and motor overloading.

8. Examine operating controls. Make sure the compressor is starting and stopping at the proper settings. If it is a dual installation, make sure they are alternating if so designed. Inspect gage for accuracy. Compare readings with recorded start up values or other known, accurate readings.

9. Many portable compressors are equipped with tool oilers on the receivers. These are used for mixing a small quantity of oil with the compressed air for lubrication of the tools being used. These are located on the discharge side of the air receiver. They have a reservoir which must be filled with rock drill oil.

10. All compressors should be thoroughly cleaned at least monthly. Dirt, oil, grease, and other material must be thoroughly cleaned off the compressor and surrounding area. Compressors have a tendency to lose oil around piping, fittings and shafts; thus constant cleaning is required by the maintenance worker to insure proper and safe operation.

QUESTIONS

8.4A List some of the uses of a compressor in connection with operation and maintenance of a wastewater collection system.

8.4B How often should the suction filter of a compressor be cleaned?

8.4C How often should compressor oil be changed?

8.4D How often should the condensate from the air receiver be drained?

8.4E What must be done before testing belt tension on compressors with your hands?

8.5 LUBRICATION

8.51 Purpose of Lubrication

Lubrication of equipment is probably one of the most important phases of a maintenance worker's job. Without proper lubrication the tools and equipment used for operating and maintaining wastewater collection systems would fail. Proper lubrication of tools and equipment is probably one of the maintenance workers easiest jobs, but often it is the most neglected.

The purpose of lubrication is to reduce friction between two surfaces. Lubrication also removes heat that is caused by friction. Solid friction of two dry surfaces in contact is changed to a fluid friction of a separating layer of liquid or liquid lubricant. Actually water is a lubricant, although a poor lubricant.

8.52 Properties of Lubricants

A good lubricant must have the following properties:

1. Form a slippery coating on contacting surfaces so they can slide freely past each other.

2. Exert sufficient pressure to keep the surfaces apart when running.

To be a good lubricant for a particular job, the lubricant used must have the following qualities:

1. Thickness of the lubricant layer must be sufficient to keep the roughness of the metal parts from touching.

2. Lubricity (slipperiness) must be sufficient to allow molecules to slide freely past each other.

3. Viscosity (resistance to flow) must be sufficient to build up a pressure necessary to keep the surfaces apart. If viscosity alone cannot provide enough pressure, an external pressure must be supplied by a pump.

Viscosity in the United States is the number of seconds it takes 60 cubic centimeters (cc) of an oil to flow through the standard orifice of a Saybolt Universal Viscometer at 100, 130, or 210 degrees Fahrenheit. A 300 - SSU[8] @ 130 oil means that it took 300 seconds for 60 cc to flow through a Saybolt Universal Viscometer at 130 degrees Fahrenheit. Viscosity decreases with temperature rise because oil becomes thinner. The specific gravity of an oil is measured by comparing the weight of oil with an equal volume of water, both at 60 degrees Fahrenheit.

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[8] SSU. Standard Saybolt Units.

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Some other important information to know about lubricants is their "Pour Point," "Flash Point," and "Fire Point." "Pour Point" is the temperature at which a lubricant refuses to run. This is important in low temperature work. "Flash Point" is the temperature at which oil vaporizes enough to ignite momentarily when near a flame. A low flash point means that oil evaporates more readily in service. "Fire Point" is the temperature at which oil vaporizes enough to keep on burning. Oils in service tend to become acid and may cause corrosion, deposits, sludging and other problems. Oils, therefore, have a neutralization number. The neutralization number is the weight in milligrams of potassium hydroxide required to neutralize one gram of oil. This is used by laboratories which test the oil on large engines, turbines, compressors, and other equipment which have large volume oil reservoirs to determine when oil changes or additives are needed.

Most lubricants in general use are fluid at room temperature. Mostly, these are petroleum base, but others are used. Greases are mixtures of petroleum products with soaps such as lime, soda, aluminum, and metallic. Metallic soaps, forms of calcium, sodium, potassium, and lithium, have good retention in bearings and can withstand high temperatures and pressures. A sodium base grease has sodium as the soap mixed with the petroleum.

Solid materials such as graphite, finely ground mica, asbestos, and yarn are sometimes used as lubricants. Some recently developed silicon compounds (silicones) work very well under heavy loads and widely varying temperatures.

There are many oil additives on the market today and they are worth investigating. Oil additives are chemical compounds added to an oil to improve certain chemical or physical properties such as stability, lubricity and foaming. They are used to prevent rust or deposits and many other items that could cause problems.

8.53 Lubrication Schedule

To have proper lubrication you must first set up a lubrication schedule. This can be a simple check-off sheet or card system or an elaborate computer system. The first thing to do is make a list of everything that needs lubrication down to the smallest item, including chains, rollers, and sprockets. After you have listed every item on paper, go through the manufacturer's instruction books to determine the frequency and type of lubrication required. Is the frequency daily, weekly, monthly, semi-annual, or annually? The manufacturer's literature usually lists several different name brands of lubricants which are equal. If you need help determining the type of lubricant or cross referencing it to your particular brand, contact your supplier. Most oil distributors have a service representative who will come to your facility and go over the individual equipment and specify which lubricant of his brand you should use. Next, determine the amount of each lubricant required. This is achieved by counting the number of grease fittings. Determine the locations of fill plugs, drain plugs, oil levels, sight glasses, dip sticks and other important items. To find these locations, physically inspect each piece of equipment thoroughly and look for all lubrication points. Also the manufacturer's maintenance manual should show the lubrication points for each piece of equipment.

When you have gathered all this information, transfer it to the equipment history cards for future reference. From this information you can make up a lubrication chart (Fig. 8.33).

As stated earlier, use whatever type of lubrication form you prepare, but follow it. Always record each lubrication job when completed and have the worker who did the job initial the record card. Always keep your lubrication schedules up to date. If there are failures due to the wrong or insufficient lubricant, change or increase the lubrication frequency on the schedule. Also, new equipment must be added and discarded equipment removed from the schedule. Someone must be assigned to take care of the lubrication and records. Assign more than one worker or rotate this job so if an individual is off work or leaves the crew, there is a continuity in the lubrication schedule.

8.54 Precautions

When handling or storing oils and greases, some special precautions must be followed. Make sure the storage area does not create a fire hazard. Most all lubricants are highly flammable and shouldn't be stored where there is an open flame. "NO SMOKING" signs must be posted outside the building. Be sure to keep any spills wiped up and make sure that all the lids are tight on their containers.

Balling Rig #2

Item	Lubricant	Change
Motor.	Heavy Duty #30	Every 3 months.
Brakes.	Brake Fluid #500	Monthly (check).
Universals.	Grease. F-2	Monthly.
Air Cleaner Bath.	SAE #20	Quarterly.
Wheel Bearings.	Grease. Wheel Type	Semi-annual.
Power Steering.	Red Line ATF #30	Quarterly (check).
Transmission.	Red Line ATF #30	Quarterly (check).
Aux. Engine on Rear	H.D. #30	Weekly.
Gear Box on Reel.	Worm Gear. #90	Quarterly.
Cable Spool.	Grease. F-2	Daily.
Sheave on Level Wind.	Grease. F-2	Daily.
Upper Bearings on Level Wind.	Oil. #20	Weekly.
Chain Drive.	Oil. #10	Monthly.

Fig. 8.33. Lubrication chart.

When storing lubricants, cleanliness is of utmost importance. A grease pail or oil drum which has become contaminated with dirt, water, or other material should be discarded. Contaminated lubricants will ruin the equipment you are trying to protect. Try using grease cartridges instead of grease pails because they are easier to keep clean and store. Grease cartridges are easy to load in the grease gun and can be discarded when empty. They cost a little more initially, but the savings in handling and a reduction in the chance of contamination may make them cheaper in the long run.

Proper equipment lubrication requires very special care when installing lubricants.

Greasing

1. Shut off, lock out, and tag unit being greased so you won't be injured if the equipment should start unexpectedly.
2. Use the proper grease.
3. Make sure grease is clean and free of dirt.
4. Pump a small amount of grease into a rag and wipe off end of grease gun.
5. Clean grease fitting to be greased with a clean rag. If a plug is to be removed, clean area around plug before removing plug and inserting grease fitting.
6. Remove any relief plug before pumping in grease.
7. Pump in the proper amount of grease as indicated on the equipment card.
8. Wipe off all excessive grease around unit.
9. Clean vent before replacing vent plug to allow for expansion of grease and to allow excess grease to work out of bearing.
10. Replace vent plugs. Do not completely fill a grease cavity and tighten vent plugs on cold grease. Leave one vent plug loose and run equipment to force excess grease out during warm up. After warm up, tighten last vent plug.

11. Record the date and your initials on the lubrication record.

12. Record and describe any unusual conditions.

Oiling

1. Make sure that the equipment being serviced is shut off, locked out and tagged out of service so you won't be injured if the equipment should start unexpectedly.

2. Check to make sure oil is the proper type and grade, as indicated on the equipment record card.

3. Wipe area around fill and drain plugs with clean rag. Also, wipe off top of oil can and cap.

4. Place container under drain plug and remove it along with the fill plug.

5. Make sure all the oil is drained out and reinstall drain plug or plugs.

6. Pour in new oil. If a funnel or spout is used, be sure to wipe it clean before starting. Fill to proper level in sight glass or dip stick. Do not overfill.

7. Install fill plug or plugs and wipe up any excess or spilled oil.

8. After equipment has been started, observe oil level to make sure it is at proper level.

9. Record the date, lubricant, and your initials on the lubrication record.

10. Record and describe any unusual conditions.

11. Place all caps on oil containers and return them to their storage place along with the funnels, pumps, and whatever else was used.

8.55 Final Clean Up and Inspection

When lubrication is completed, make sure all oily rags and materials are placed in a covered metal can while waiting to be picked up or disposed of. If it is necessary to transfer oil to different cans, make sure they are labeled properly. Never leave an open oil can laying around to use when the unit needs more oil.

After your lubrication is completed, inspect the equipment in a few hours to make sure it is not overheating or making any strange or unusual noise. Examine the oil levels to make sure they are at their proper level. Proper lubrication is the key to successful equipment maintenance.

QUESTIONS

8.5A What is the purpose of lubrication?

8.5B What happens to oils in service?

8.5C What should be done to insure proper lubrication of equipment?

8.5D What should be done when lubrication failures occur?

8.5E What precautions must be taken when handling or storing oils and greases?

8.5F What precautions must be taken before oiling or greasing equipment?

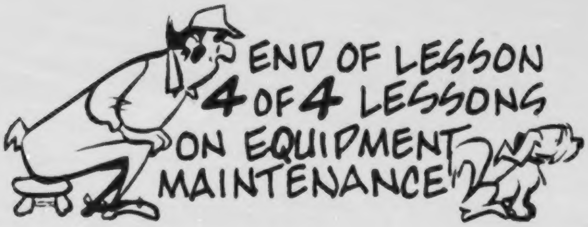
8.5G What should be done after lubrication job is completed?

8.6 ADDITIONAL READING

1. "Maintenance and Repair of Equipment for Water Supply and Sewerage Systems," Major C. Hagar, Environmental Health Services, Kansas State Department of Health, Topeka, Kansas or Oklahoma State Department of Health, Oklahoma City, Oklahoma.

1093

2. "Maintenance Engineering Handbook," Second Edition, by L. C. Morrow, Editor, McGraw-Hill Book Company, New York, New York, Price $39.50.


END OF LESSON
4 OF 4 LESSONS
ON EQUIPMENT
MAINTENANCE

DISCUSSION AND REVIEW QUESTIONS

Chapter 8. Equipment Maintenance

(Lesson 4 of 4 Lessons)

Write the answers to these questions in your notebook before continuing to the objective test on page 8-165. The problem numbering continues from Lesson 3.

20. What are the uses of a compressor?

21. What items should be maintained on a compressor?

22. How would you develop a lubrication schedule for a pump?

23. Why is cleanliness important in the storing and use of lubricants?

24. How would you clean up after a lubrication job is completed?

SUGGESTED ANSWERS

Chapter 8. Equipment Maintenance

8.1A Unqualified or inexperienced people must be extremely careful when attempting to trouble shoot or repair electrical equipment because they can be seriously injured and damage costly equipment if a mistake is made.

8.1B When machinery is not shut off, locked out, and tagged properly, the following accidents could occur:

1. Maintenance worker could be clearing pump and have it start, thus losing an arm, hand, or finger.
2. Electrical motors or controls not properly grounded could lead to possible severe shock, paralysis, or death.
3. Improper circuit -- wrong connection, safety devices jumped, wrong fuses, or improper wire. These mistakes can cause fires, or injuries due to incorrect operation of machinery.

8.22A The two types of voltage are Direct Current (D.C.) and Alternating Current (A.C.).

8.22B Amperage is a measurement of work being done or "how hard the electricity is working".

8.22C The proper voltage and allowable current in amps for a piece of equipment can be determined by reading the name plate information or the instruction manual for the equipment.

8.23A You test for voltage by using a voltage tester.

8.23B A voltage tester can be used to test for voltage, open circuits, blown fuses, single phasing of motors and grounds.

8.23C Before attempting to change fuses, turn off power and check both power lines for voltage. Use a fuse puller.

8.23D If the voltage is unknown and the volt meter has different scales that are manually set, always start with the highest voltage range and work down. Otherwise the voltmeter could be damaged.

8.23E Amp readings different from the name plate rating could be caused by low voltage, bad bearings, poor connections, plugging or excessive load.

8.23F Motors and wirings should be megged at least once a year, and twice a year if possible.

8.23G An ohm meter is used to test the control circuit components such as coils, fuses, relays, resistors and switches.

8.24A The two types of safety devices in main electrical panels or control units are fuses or circuit breakers.

8.24B Fuses are used to protect workers, wiring, circuits, heaters, motors, and various other electrical equipment.

8.24C A fuse must never be by-passed or jumped because the fuse is the only protection the circuit has; and without it, serious damage to equipment and possible injury to workers can occur.

8.24D A circuit breaker is a switch that is opened automatically when the current or the voltage exceeds or falls below a certain limit. Unlike a fuse that has to be replaced each time it "blows", a circuit breaker can be reset after a short delay to allow time for cooling.

8.25A Motor starters can be either manually or automatically controlled.

8.25B Magnetic starters are generally used to start pumps, compressors, blowers and anything where automatic or remote control is desired.

8.26A Electrical energy is commonly converted into mechanical energy by electric motors.

8.26B An electric motor usually consists of a stator, rotor, end bells, and windings.

8.26C Motors can be kept trouble free with proper lubrication and maintenance.

8.26D Motor name plate data should be recorded, compared with manufacturer's data sheets and instructions, and placed in a file for future reference. Many times the name plate is painted, corrodes or is missing from the unit when the information is needed to repair the motor or replace parts.

8.27A The key to effective trouble shooting is practical, step-by-step procedures combined with a common sense approach.

8.27B When trouble shooting:

A. Gather preliminary information.

B. Inspect:
   1. Contacts
   2. Mechanical parts
   3. Magnetic parts.

8.28A Types of information that should be recorded regarding electrical equipment includes every:

1. Change
2. Repair
3. Test.

8.31A Pumps are used to move or lift wastewater in collection systems and treatment plants. They also are used to pump water in high velocity cleaners and to dewater construction projects. In addition, backhoes have hydraulic pumps and automobiles have oil pumps.

8.31B If we know how a pump is built, it is easier to understand how to operate and maintain a pump.

8.31C Pump lubricants should be changed in accordance with the pump manufacturer's lubrication instructions. If the instructions are not available or if in doubt, call the supplier for recommendations. Play it safe and change the lubricant before it's too worn or too dirty. Look at the lubricant after the pump has run at equilibrium temperature. Any used oil or oil needing change will become discolored and turn grey or black.

8.31D A pump is in proper alignment if the pump and motor flanges are parallel vertically and axially...and kept that way.

8.31E Horizontal suction lift piping must always slope upward towards the pump to prevent air pockets and loss of suction.

8.31F Piping can be kept from straining the pump casing by (1) being properly supported, and (2) regular inspection to be sure the pump or piping has not shifted or settled and caused a strain. Look for evidence of a heavy object in contact with the piping that could have caused misalignment and/or a strain.

8.31G A pump should never be allowed to run dry because water acts as a lubricant between the wearing rings and the impeller.

8.33A Impellers should be inspected on a regular basis such as every 6 months or annually, depending on pumping conditions. If grit, sand, or other abrasive type of material is being pumped, inspections should be more frequent.

8.33B Wearing rings protect the impeller and pump body from damage due to excessive wear.

8.33C If pump clearances are not kept in proper adjustment, the pump may become plugged frequently, shaft scoring is more likely, and power requirements will increase due to lowered efficiency.

8.33D An impeller shows cavitation damage if it has pits on the surface.

8.33E Cavitation can be caused by a pump operating under different conditions than what it was designed for, such as, off the design curve, poor suction conditions, high speed, air leaks into suction end and water hammer conditions.

8.34A Pump shafts can be protected from damage by the installation of shaft sleeves over the shaft in the area on the shaft where it passes through the stuffing box.

8.34B A pump shaft sleeve must be replaced when grooves are observed.

8.35A Packing or mechanical seals are used to keep water from leaking out where the shaft passes through the casing.

8.35B The lantern ring is used to allow outside water or grease to enter the packing for lubrication, flushing, and cooling.

8.36A A pump with a mechanical seal (or any other type of seal) should never be run dry because water is required for seal lubrication.

8.36B Mechanical seals are not supposed to have any leakage from the gland; and if a leak develops, the seal may require relapping or it may have to be replaced.

8.37A The different types of bearings used in pumps include ball bearings, roller bearings, and sleeve bearings.

8.37B Whenever a bearing failure occurs before its expected replacement time, the bearing should be examined to determine the cause, and if possible, to eliminate the problem.

8.37C The different types of bearing failures include fatigue failure, contamination, brinelling, false brinelling, thrust failures, misalignment, electric arcing, lubrication failure, and cam failure.

8.37D Contamination failure of a bearing can be caused by dirty or damp surroundings or abrasive waste materials. Contamination failure can be prevented by removing the source of contamination.

8.37E Bearing failures from misalignment can be prevented by insuring proper alignment of pump shaft and housing.

8.37F Bearing lubrication failures can be identified by grease appearance, abnormal temperature rise, noise, bearing discoloration, and retainer failure.

8.38A Couplings are used to couple a source of power to the shaft of a pump impeller.

8.38B Methods by which a pump and driver can be coupled together include direct coupled, belt driven, flexible shafting and closed-coupled.

8.38C The functions of a flexible coupling include transmitting power from one shaft to the other, decreasing wear on shaft bearings and driven equipment, accomodating slight shaft misalignments, absorbing shock loads and pulsations, dampening vibrations, accomodating load reversals, minimizing initial backlash, and making assembly and disassembly easy.

8.38D To inspect for proper alignment, look for parallel and angular misalignment using feelers --- a straight edge placed squarely across the rings of the coupling halves. Place the feelers at the top, bottom, near and far sides of the coupling junctions. Also place the feelers along the edge of top and sides of the shaft. Dial indicators also may be used.

8.38E When inspecting clearance between faces of coupling halves, be sure they are set so they cannot strike, rub, or exert a pull on either machine.

8.38F An advantage of driving a pump with belts is that different speed ratios can be achieved between the motor and pump. Also the motor can be placed in a variety of positions with respect to the pump.

8.38G All belts on a pump must be replaced at the same time with a matched set so all belts will wear evenly.

8.38H Belts and sheaves must be kept clean to reduce wear on both belts and sheaves.

8.38I Alignment of pump and motor sheave can be determined by (1) placing a straight edge between the two pulleys or (2) pulling a string across both pulleys.

8.38J Proper belt tension is achieved when the belts have only a slight bow on the slack side of the belt drive while operating under load, or when belts have a 3/4-inch movement from hand pressure at mid-point of back belt when unit is off.

8.38K If belts squeal during start up, reposition motor adjustment to increase tension until slippage and squeal disappear.

8.38L When belts are adjusted too tight, problems can result, such as, bearings heating and excessive belt wear.

8.38M Flexible shafting is installed where the pump and driver are located relatively far apart.

8.38N Universal joints should be lubricated every 200 hours during continuous service and every 500 hours during intermittent service. Consult manufacturer's literature for type of lubricant and details.

8.380 Failure of a bearing in a universal joint can be indicated if

1. Grease does not come out all four bearings when greasing,
2. Brown powder appears in the area of one bearing, or
3. Rough, uneven play occurs when the yoke is moved.

8.4A Compressors are used with wastewater ejectors, pump control systems (bubblers), valve operators, and water pressure systems. Also they are used to operate portable pneumatic tools such as jack hammers, compactors, air drills, sand blasters, tapping machines, and air pumps.

8.4B The frequency of cleaning a suction filter on a compressor depends on the use of a compressor and the atmosphere around it. The filter should be inspected at least monthly and cleaned or replaced every three to six months. More frequent inspection, cleaning and replacement are required under dusty conditions such as operating a jack hammer on a street.

8.4C Compressor oil should be changed at least every three months, unless manufacturer states differently. If there are filters in the oil system, these also should be changed.

8.4D Drain the condensate from the air receiver daily.

8.4E Before testing belt tension on a compressor with your hands, make sure compressor is locked off.

8.5A The purpose of lubrication is to reduce friction between two surfaces and to remove heat caused by friction.

8.5B Oils in service tend to become acid and may cause corrosion, deposits, sludging and other problems.

8.5C To insure proper lubrication of equipment, determine the proper lubrication schedule, lubricant, and amount of lubricant and prepare a lubrication chart.

8.5D When lubrication failures occur, try to identify cause and change lubricant and/or frequency of lubrication if necessary.

8.5E Oils and greases can create a fire hazard. All spills must be wiped up immediately. Oils and greases must not become contaminated with dirt, water or other material.

8.5F Before oiling or greasing equipment, shut it off, lock it out and tag it so it won't start unexpectedly and injure you.

8.5G After lubrication job is completed, clean up area, properly store or dispose of oily rags and materials, and inspect lubricated equipment in a few hours to make sure it is not overheating or making any strange or unusual noises.

OBJECTIVE TEST

CHAPTER 8. EQUIPMENT MAINTENANCE

Please mark correct answers on answer sheet as directed at end of Chapter 1. There may be more than one correct answer to each question.

1. Maintenance workers should not do actual electrical repairs or trouble shooting because
    1. It is too dangerous.
    2. This is a highly specialized field.
    3. Costly damage can be done to equipment by unauthorized persons.
    4. Many are not adequately trained.
    5. They realize their own limitations regarding electrical work.
2. What information must be on a warning tag attached to a locked out switch?
    1. Signature of person who locked out switch and who is the only person authorized to remove tag.
    2. Time to unlock switch.
    3. Directions for removing tag.
    4. Name of equipment.
    5. Name of company that printed warning tag.
3. Who is qualified to work in an electrical panel?
    1. Maintenance Man I.
    2. Maintenance Man II.
    3. Supervisor.
    4. Crew Leader.
    5. Electrician.
4. A voltage tester is used to test for
    1. Intensity of voltage.
    2. A.C. or D.C.
    3. Amps.
    4. Watts.
    5. Blown fuses.

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5. Equipment name plate data must be recorded and filed because

   1. The information is needed to order replacement parts.
   2. The manufacturer doesn't keep the information.
   3. The name plate could get lost.
   4. The name plate could become corroded.
   5. The filing cabinet is supposed to have this information.

6. What could be the cause of a pump electric motor not starting?

   1. Pump not hooked to motor.
   2. No power supply.
   3. Rotating parts of motor may be jammed mechanically.
   4. Fuse or circuit breaker out.
   5. Incorrect power supply.

7. Wearing rings are installed in a pump to

   1. Keep the impeller in place.
   2. Wear instead of impeller.
   3. Plug internal water leakage.
   4. Hold the shaft in position.
   5. Wear out the sleeves.

8. Maintenance of pneumatic ejectors includes:

   1. Cleaning the interior of the pots to remove grease.
   2. Inspecting valves, floats and electrical controls for proper operation.
   3. Maintaining the motor and air compressor.
   4. Cleaning air strainer between ejector receiver and main air valve.
   5. Observing several cycles to be sure everything is operating properly.

9. Before inspecting an impeller you should

   1. Turn off and lock out all electrical power to pump.
   2. Tag control panel.
   3. Close suction and discharge valves.
   4. Drain pump with bolts still in handhole cover until water flow stops.
   5. Open handhole covers and visually inspect for foreign objects which may injure you.

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10. When inspecting a pump impeller you should look for

1. Cavitation marks.
2. Chips, broken tips, corrosion or unusual wear.
3. Tightness on shaft.
4. Clearances.
5. Water in water seal.

11. Grooves can be cut into pump shafts by

1. Razor blades.
2. Glazed packing.
3. Motor rotor rubbing on stator.
4. Wrong type of packing.
5. Dirty seal flushing water.

12. If packing is not maintained properly, the following troubles can arise:

1. Packing needs more lubricant.
2. Loss of suction due to air being allowed to enter pump.
3. Shaft or shaft sleeve damage.
4. Flooding of pump station.
5. Must develop a new maintenance schedule.

13. Some of the advantages of mechanical seals over packing include:

1. Lower initial cost.
2. They last longer, thus resulting in labor savings.
3. Continual adjusting, cleaning, or repacking is not required.
4. Pump does not have to be dismantled for repair.
5. Usually there isn't any damage to shaft sleeve when they need replacing.

14. Types of bearing failures include

1. Fatigue.
2. Insufficent loading.
3. Contamination.
4. Misalignment.
5. Balling.

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15. The main functions of flexible couplings are

1. To allow shaft to bend.
2. To transmit power from one shaft to another.
3. To keep the shaft tight.
4. To decrease wear on shaft bearings.
5. To accomodate for slight shaft misalignments which develop in service.

16. Compressor maintenance includes

1. Inspecting the suction filter of the compressor regularly.
2. Keeping the belts as tight as possible.
3. Examining the oil reservoir dip stick or sight glass.
4. Cleaning cylinder or casing fins weekly.
5. Washing off the compressor weekly.

17. The following precautions must be exercised when handling or storing lubricants:

1. Do not create a fire hazard.
2. Keep lids tight on containers.
3. Wipe up spills.
4. Discard lubricants that become contaminated with water or dirt.
5. Post "NO SMOKING" signs on the outside of buildings where lubricants are stored.

18. What is the purpose of an equipment preventive maintenance program?

1. To keep workers looking at equipment.
2. To protect the public's investment spent buying the equipment.
3. To insure proper and efficient operation of the equipment.
4. To provide jobs for workers when they visit a facility.
5. To extend equipment life.

19. When belts are used to drive equipment, important considerations include:

1. Proper number of belts.
2. Belts must be matched sets.
3. Noise or squeal on start up can be corrected by proper tension.
4. Belt dressing should be used monthly for pliability of belts.
5. Guards are required on all belt drives that are exposed.

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20. The following types of pumps are commonly encountered by collection system workers on the job:

    1. Screw pumps.
    2. Centrifugal pumps.
    3. Diaphragm pumps.
    4. Rotary pumps.
    5. Submersible pumps.

Review Questions

21. Safety precautions that must be considered during underground work include:

    1. Protection from cave-ins.
    2. Adequate ventilation
    3. Protection of the public from injury.
    4. Protection of private property.
    5. Protection of the worker from traffic.

22. Selection of proper shoring and use of shoring requires consideration of

    1. Worker safety.
    2. Soil conditions.
    3. Trench location.
    4. Access to construction work area.
    5. Pedestrian safety.

CHAPTER 9

SAFETY FOR THE COLLECTION SYSTEM WORKER

by

Glenn Davis

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by Glenn Davis

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OBJECTIVES

CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

After completion of Chapter 9 you should be able to do the following:

1. Describe the importance of safe procedures and practices for the collection system worker.
2. Identify potential and existing hazards.
3. Test the atmospheres in confined spaces for oxygen deficiency, poisonous or toxic conditions, and explosive levels.
4. Properly ventilate confined spaces.
5. Drive safely.
6. Determine when shoring is required.
7. Recognize potential causes of cave-ins.
8. Outline procedures for safely entering confined spaces.
9. Route traffic around work areas in or near streets.
10. Prepare and present effective safety programs.
11. Extinguish fires.
12. Provide emergency first aid treatment.

NOTE: Special safety information is given in the other chapters because of the importance of safety considerations at all times. All procedures in this manual follow safe procedures and identify precautions that must be taken to do a SAFE JOB.

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CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

(Lesson 1 of 3 Lessons)

9.0 SAFETY

9.01 Survival

Throughout the world most living things devote considerable energy, time, and thought to survival. With every level of life, be it human beings, animals, insects, fish or fowl, survival occupies a great part of every living hour.

Intelligent people not only try to protect themselves from injury or death, but they also strive to protect their fellow human beings and especially their immediate families and co-workers. All of our struggles for achievement are useless if we cannot protect outselves from disabling injury or death. An accident is a tragedy for your family and others who depend on, and love you, as well as for yourself.

9.02 Professionalism

Probably no skill most marks the professionalism of the collection system worker more than the worker's ability to carry out work assignments safely. An amateur can perform many of the tasks of a collection system worker, but with more hazard to the equipment, fellow workers and himself. The true professional worker always instills confidence in the worker's ability to do a job well - generally quicker and better - but ALWAYS MORE SAFELY.

An important consideration for promotion is how well a worker is able to gain the confidence and support of others. The abilities to perform, motivate, train and lead others are important supervisor characteristics that gain promotion. A reputation for a dependable, safe performance is an important professional characteristic of a collection system worker as well as of any other craftsman.

9.03 High Hazards

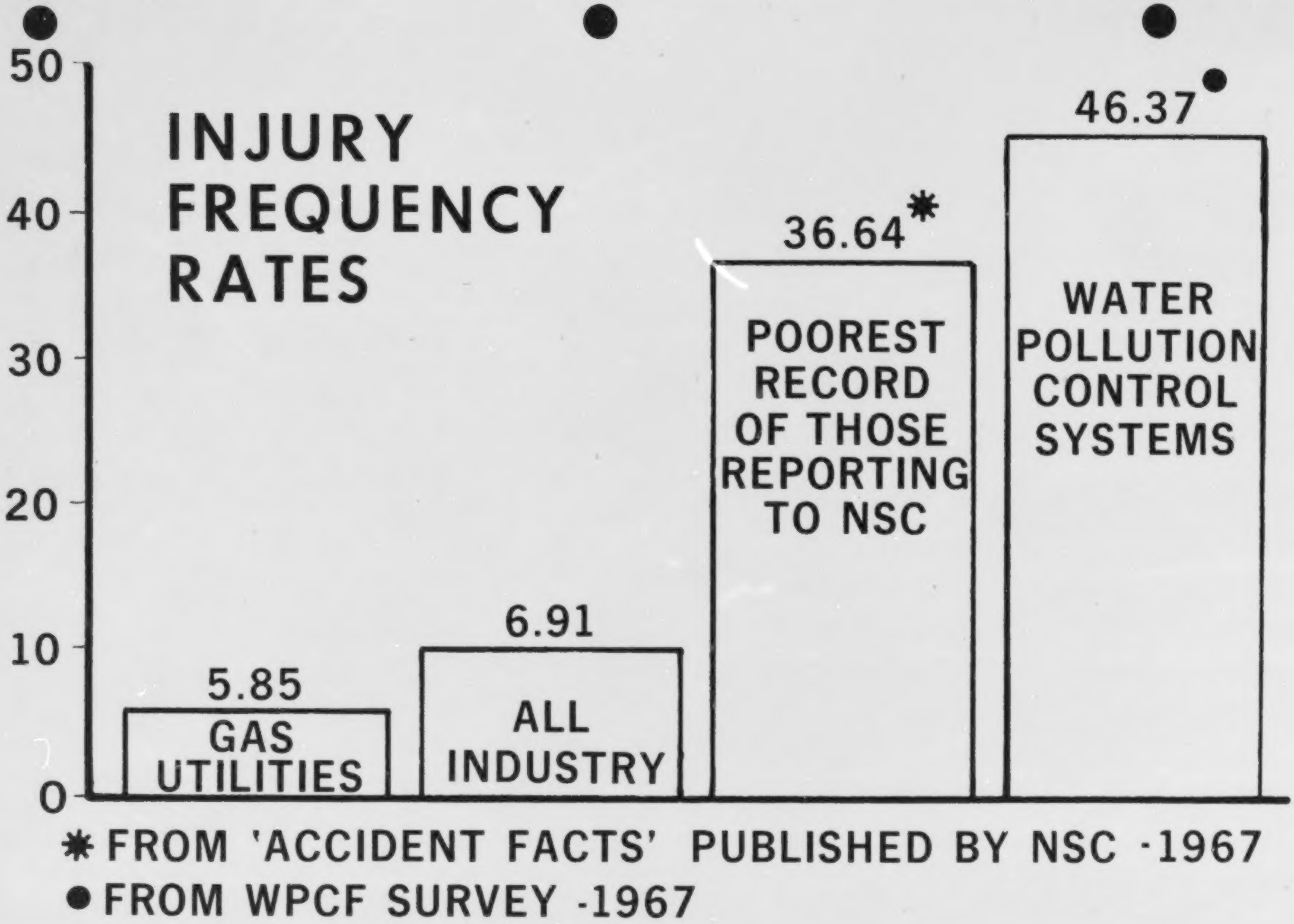
In 1967 the National Safety Council reported that the water pollution control industry was second only to underground mining in lost time accidents.[1] Following this report the Water Pollution Control Federation, using information gathered from a new system of more complete safety records, reported a greater accident frequency (lost time accidents per million man-hours worked) for the water pollution control industry (Figure 9.1). The more complete statistics also showed that the collection system worker's safety record was approximately twice as bad as the record for workers in wastewater treatment plants (Figure 9.2). Unfortunately, the collection system worker is in one of the most hazardous parts of one of the most hazardous occupations with a record that demands maximum attention to safety. No ambitious, intelligent, and well trained collection system worker can overlook these facts if you want to continue living on the job and be successful in your work.

In spite of the fact that the collection system worker's safety record was poor in 1967, statistics gathered since then show no overall improvement in this bad record (Figure 9.2)! WHY? Analysis of the records reveals that the main reason for this high accident rate is negligence on the part of the workers.[2] There is no excuse for negligence. Decide now that you and the members of your crew will not become accident victims. Learn how to do the job safely and do it safely.

---

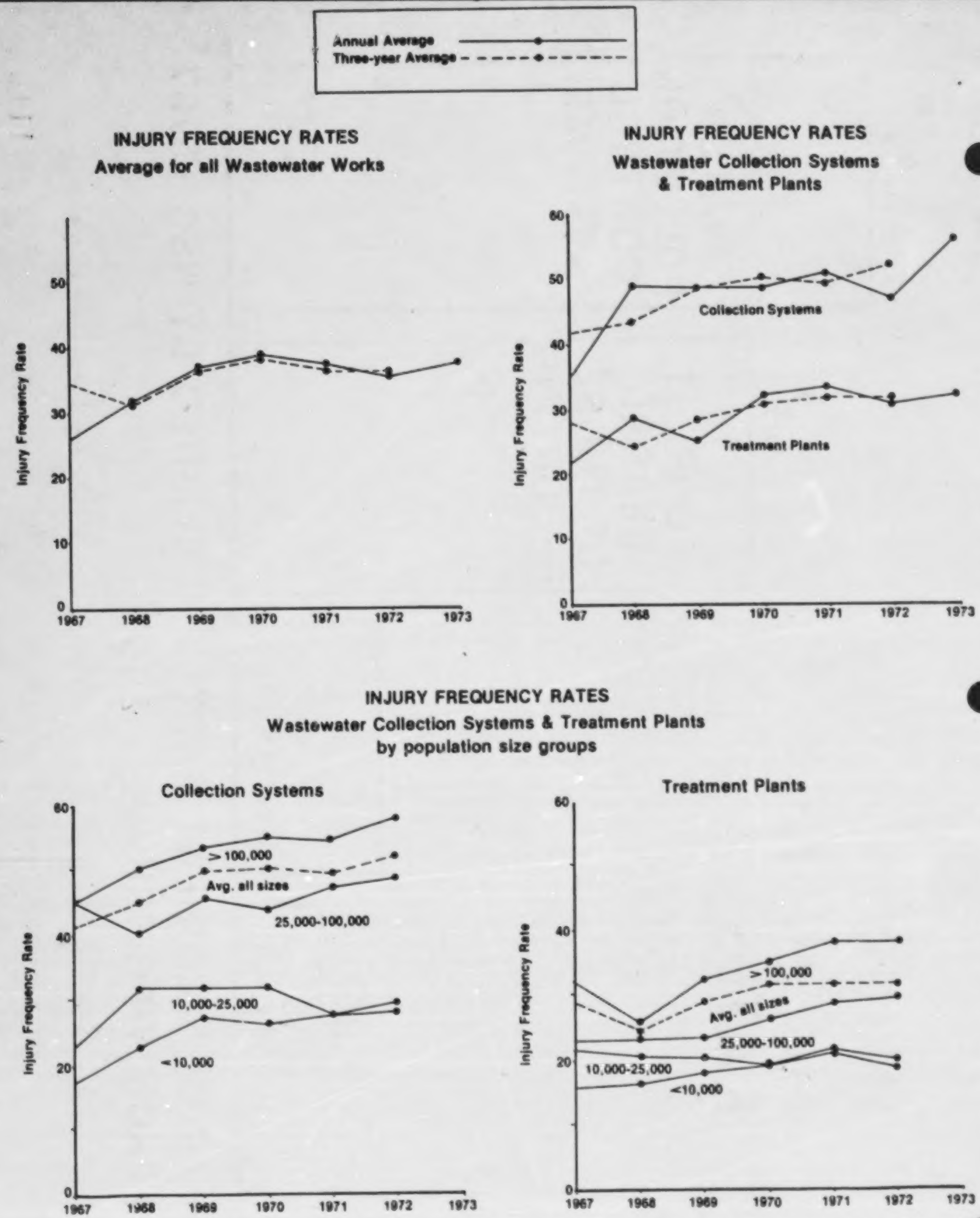
[1] "Accident Facts", 1967 Edition (1966 accidents), prepared by the Statistics Division, National Safety Council, Chicago, Illinois 60611.

[2] Wagner, V.G., "How Safe are Sewers for Construction and Maintenance Crews", Deeds & Data, Water Pollution Control Federation, April, 1974.



Injury frequency rates--number of lost time accidents per million man-hours worked during 1967.

Fig. 9.1. Injury frequency rate in the water pollution control industry (Courtesy Water Pollution Control Federation)



Injury frequency rate--number of lost time accidents per million man-hours worked per year.

Fig. 9.2. Trends in frequency injury rates.

(Source: Deeds & Data, Water Pollution Control Federation, February 1975)

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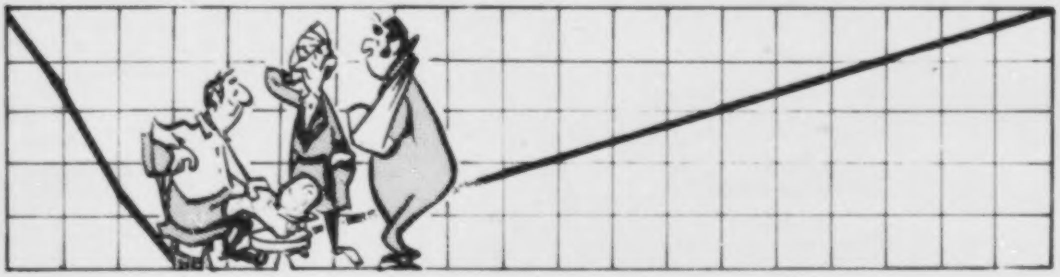
REMEMBER: "ACCIDENTS DON'T JUST HAPPEN--THEY ARE CAUSED!!" How true it is! Behind every accident there is a chain of events which lead to an unsafe act, unsafe condition, or a combination of both. ALWAYS THINK SAFETY!

9.04 Other Industries by Comparison

The history of many other industries throughout this nation who have improved their safety records when confronted with poor safety statistics shows that our safety record can be improved. To do this, however, requires that the causes of this poor record be identified. The major safety problem in the water pollution control industry has been traced to NEGLIGENCE in training, planning and doing our jobs. Generally, as soon as other industries have discovered their records were bad and the hazards were great, the statistical curves for lost time accidents head downward after appropriate action is taken. Some industries averaged less than five lost time accidents per million man-hours worked while the figures for the water pollution control industry have been over 46 lost time accidents per million man-hours worked.

To improve or to maintain a good safety record require hard work by managers, supervisors and workers all trying together. If you don't keep trying all the time, someone is going to get hurt. Safety records usually either slowly get better or slowly get worse. If the history of other industries can be applied to the water pollution control industry, the time is NOW for us to start and to continue a downward trend in accident rates so our profession can become a safer public service industry. One water pollution control plant started out with a new facility and new workers and three lost time accidents during the first six months of operation.



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After the organization of a regular safety program, the record for this same plant for the next eight years was over one and a quarter million man hours without a lost time accident.

The simple desire to understand what causes accidents and how they can be prevented, coupled with a strong desire to work safely, has produced improvement throughout the nation in other industries and will work for the water pollution control industry.

9.05 A Definition of Safety

Safety has been defined as, "a means of thinking far enough ahead to do the job at hand with proper tools at the proper time and in the proper manner."

An accident is an unplanned event. It is merely a word until it happens to you; then, too late, you realize the pain, suffering, and personal and family loss that it may include.

9.06 Hazards

Wastewater collection system workers are exposed to many hazards. Accidents can occur from the following:

1. Falls

2. Falling objects
3. Infections
4. Scrapes or cuts
5. Explosions
6. Toxic gases
7. Suffocation
8. Strains or ruptures

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9. Traffic mishaps
10. Bites (insects, bugs and rodents)
11. Cave-ins and structural failures
12. Drowning
13. Fire
14. Electrical shock
15. Noise.

Throughout this entire manual we have attempted to describe safe procedures so you could avoid these hazards and prevent accidents. This chapter reviews and summarizes these procedures to stress the need for safety at all times. Also included in this chapter are suggestions on how to develop an effective safety training program using the material in this chapter.

9.07 Approved Procedures and Equipment

To avoid accidents and any resulting legal action, everyone should follow approved procedures and use approved equipment. What is approved? Some federal and state agencies approve procedures and equipment and others do not. Sometimes something is approved and then it is disapproved. Some states might approve something and other states might not. To find out what is approved and what isn't, contact your state industrial safety officer and other state agencies that might be able to assist you. Unfortunately many state agencies don't have the manpower or budget to test and approve new equipment when it becomes available. This situation should improve in the future as we demand safer working conditions.

QUESTIONS

9.0A What is the First Law of Life for the collection system worker?

9.0B What skill most marks the professionalism of a collection system worker?

9.0C Why is a safe performance an important consideration for promotion?

9.0D How safe is the job of a collection system worker?

9.0E How can the poor safety statistics for collection system workers be improved?

9.0F What is safety?

9.1 INFECTION AND INFECTIOUS DISEASES

Every collection system worker must realize that wastewater is contaminated with possibly every kind of infectious microorganism that can be carried in wastewater. Like the medical doctor, the collection system worker can become exposed to many of the pathogenic organisms[3] from the entire community in which you work. Also like the doctor, personal health depends to a great extent upon your personal cleanliness. Both you and the doctor must wash your hands before smoking or eating. Recognition of these facts is apparently the main reason that neither profession generally suffer an unusually high incidence of infection. Other possible reasons include the possibility that collection system workers develop immunities to infectious diseases or the records reporting diseases are inadequate.

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[3] Pathogenic Organisms (PATH-o-JEN-nick OR-gan-iz-ums): Bacteria or viruses which can cause disease (for examples typhoid, cholera, dysentery). There are many types of bacteria which do not cause disease and which are not called pathogenic. Many beneficial bacteria are found in wastewater treatment processes actively cleaning up organic wastes.

Diseases or infections that collection system workers could come in contact with on the job include:

Typhoid and paratyphoid fevers

Cholera

Bacilliary dysentery

Amoebic dysentery

Round worm and other worm infections

Tuberculosis

Poliomyeltis

Infectious hepatitis

Leptospirosis (Weil's disease)

How can you determine if you have contacted one of these diseases? The best indication is that you don't feel well. If you have headaches, feel sick to your stomach, have diarrhoea, feel feverish or sleepy, you should see your physician. Prompt action by your physician can save you a lot of pain and trouble in the future and also help protect your family, friends and your fellow workers. See Chapter 4, Section 4.13, Classification and Description of Manhole Hazards, and Section 4.15, Precautions for Manhole Entry, for more information.

Public health officials generally agree that tetanus, polio and typhoid infections are especially hazardous for anyone coming in contact with wastewater. Typhoid once was considered the most dangerous water borne infection, but tetanus is now considered the most dangerous. Typhoid is now more easily cured by recent medical discoveries. Immunization against typhoid is only about 60 percent effective. While polio (especially Salk vaccine) immunization is effective and simple to administer, it is still a very dangerous disease (especially to younger workers). Tetanus is easy to prevent, but difficult to treat and is considered the most dangerous of the three diseases. All three diseases should be included in the collection system worker's immunization schedule with booster shots at recommended intervals.

Throughout the wastewater collection and treatment systems, harmful microorganisms can become a health hazard if the wastewater is not given proper respect and adequate personal precautions are not followed. Work gloves of the proper type should be worn when handling contaminated or sharp materials. Waterproof gloves may be necessary to protect your hands from contamination; however, heavy leather gloves can protect from nicks, cuts, scrapes, scratches and lacerations that often invite infection. To date no single glove provides maximum protection from both contamination and cuts. Several types of gloves may be necessary during a day's work. Proper first aid should always be applied when a collection system worker receives skin wounds.

Rubber gloves are suggested when direct contact with wastewater is a possibility. For example, they should be worn when repairing or cleaning sewers or when cleaning or repairing pumping or plant equipment that could be contaminated. You must realize that gloves can catch on turning equipment and trap you in a dangerous situation under certain conditions. Such equipment should be guarded or stay away from it while it is moving. Keep coats buttoned or belted when working around machinery.

QUESTIONS

9.1A How can you determine if you have contacted a disease from your work?

9.1B How can the collection system worker be protected from pathogenic organisms?

9.2 GAS HAZARDS

Gas hazards are a very special concern for the collection system worker. Many gases are heavier than air and tend to be produced or released from deposits and slimes found at the low levels or in underground structures where collection system workers must perform part of their work. These locations are frequently poorly ventilated and isolated for long periods of time before you must enter the confined space. Gases, like electricity, are unseen and therefore may be very dangerous. The well trained collection system worker is aware of potential gas hazards, their special properties, and knows that the three basic types of dangerous gases are:

1. Poisonous or toxic,
2. Explosive atmospheres, and
3. Atmospheres lacking oxygen.

Each basic class presents hazards in its own way, each has its own characteristics and each, like electricity, must be evaluated or measured (Section 9.24) by an extrasensory device (instrument or meter). Toxic hydrogen sulfide gas is the commonest gas hazard to collection system workers. Flammable gas is the next most serious hazard followed by oxygen deficient atmospheres.

9.21 Poisonous or Toxic Gases

There are a number of toxic gases that are found in the wastewater collection system. Hydrogen sulfide is the most dangerous and most likely to be encountered because it is generated from the anaerobic decomposition of organic matter and it is heavier than air. Hydrogen sulfide smells like rotten eggs and tends to concentrate near the bottom of enclosed spaces. Unfortunately our noses tend to lose their sensitivity to hydrogen sulfide and become unreliable detectors. Many workers as well as their would-be rescuers have been killed by this gas. Other toxic or poisonous gases found in collection systems include carbon monoxide, ammonia and chlorine. Industrial chemical discharges can release dangerous gases due to accidents, leaks, or illegal discharges. Toxic spills from highway and railway accidents also can reach the sewers.

QUESTIONS

9.2A Why do gases found in sewers tend to be found in low level or underground structures (confined spaces)?

9.2B What are the three basic classes of hazardous atmospheres?

9.2C What are some toxic gases that might find their way into a wastewater collection system?

9.2D Why is hydrogen sulfide especially dangerous?

9.22 Explosive Atmospheres

Anyone who has seen the results of an explosion either in a sewer, a digester, or other type of enclosure, is well aware of the havoc that can be caused by just the right explosive mixture of air and gas. Just as surely as you car will start, so will the right mixture of a combustible gas and air explode when ignited. Too rich a mixture or too lean a mixture of a combustible gas will not explode.

A spark from an automobile, an improper tool, or even a shoe nail, as well as the more obvious open flame or cigarette may set off the explosion when the mixture of air and gas is within the level of the explosive limits. Only extremely well trained and knowledgeable workers (such as gas company experts) should consider working around such dangerous atmospheres and then only when proper ventilation and hazard removal or elimination has been verified as impossible (carbon dioxide fire extinguishers have been used by experts to dilute explosive mixtures when necessary).

Experts from the gas company may be called upon in an emergency to work in or near explosive mixtures. These specially trained workers with years of experience can be trusted to perform such dangerous work if no other feasible alternatives exist. A true expert is a worker who always knows and works within his own limits with plans for back-up or alternative action if suddenly confronted with a new emergency.

Special insight can be gained by discussing explosive hazards with your local fire department personnel. They should have a knowledge of the areas that are most likely to discharge hazardous combustible materials to the wastewater system; but if they don't, it is your responsibility to locate these potentially hazardous sources. Another good way to gain assistance when searching for sources of hazardous gases is to contact your local gas company. Many times explosive conditions are caused by leaking gas mains or service lines. In combined wastewater collection systems where any spill of gasoline on a public street may find its way into the collection system, particularly hazardous conditions can develop as far as explosive mixtures are concerned.

QUESTIONS

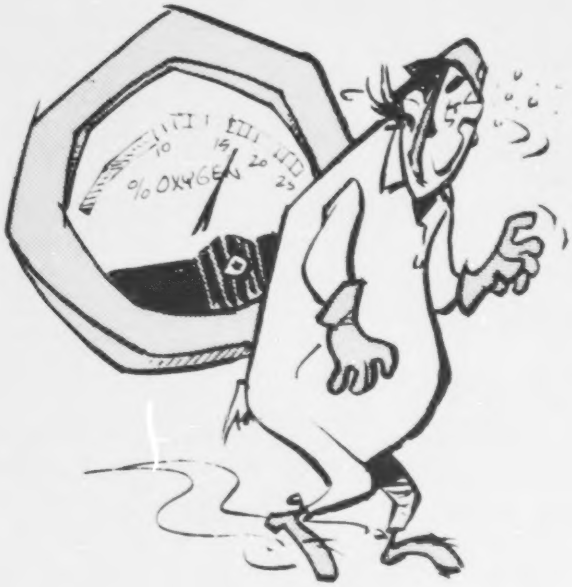
9.2E What are possible ignition sources for an explosive atmosphere?

9.2F How can you try to locate possible sources of potential explosive hazards in your collection system?

9.23 Oxygen Deficient Atmospheres

A safe supply of oxygen is essential to you in the environment in which you must work. Any concentration of other gases can reduce the amount of oxygen available for life support. A shortage of oxygen to the worker produces a shortage of oxygen to the brain, which in turn makes the worker less alert. If you are less alert, you may not recognize the danger until you are too weak to get out. Each year many workers die from toxic hydrogen sulfide, a shortage of oxygen, or from falls or unsafe acts in attempts to escape without help when the worker is mentally disabled, at least in part, by a toxic gas or insufficient oxygen.

The views of experts and legal regulations vary regarding safe levels of oxygen, as do individual needs concerning the amount of oxygen required to support life. Your health and the amount of energy expended are considerations in determining the amount of oxygen that you need. But anything less than 19.5 percent of oxygen in the breathing atmosphere is a signal to the trained collection system worker to be especially careful and request more ventilation. Measure the percent of oxygen in the air above the manhole. Anytime the percent of oxygen in a manhole starts dropping below the percent topside, increase the ventilation.



Beware of the possibility of excessively high levels of oxygen too. High oxygen levels won't harm you, but they increase the hazards of explosion and fires. Hazardous levels of oxygen can result from the use of pure oxygen for hydrogen sulfide (H_2S) control (Chapter 5, Section 5.6, Hydrogen Sulfide Control, especially Section 5.653, Pure Oxygen) in collection systems and for wastewater treatment plants in the activated sludge process. An upper limit of 21.9% oxygen in working atmospheres is suggested.

9.24 Detection of Hazardous Gases

Careful testing of the atmosphere in any enclosed space, especially below grade (ground level), is essential to be sure the environment is safe to enter. The atmosphere should be tested by instruments that measure the toxic level, the explosive level, and the oxygen level just prior to entry. Measurement of the gases present before the manhole lid is removed is important to determine the nature of any hazard, the degree of the hazard, the possibility of leaks or dumps and the type of protection needed for safe work. Single instruments (Figures 9.3, 9.4 and 9.5) are available that will measure the toxic level (hydrogen sulfide), explosive level (methane), and oxygen level and produce an audio alarm when test results indicate dangerous conditions. The reliability and accuracy of gas testing equipment should be certified by an independent laboratory at the expense of the supplier or manufacturer. The lives of workers are too valuable to rely strictly on the claims of a salesman.

To obtain the most accurate measurement of atmospheric conditions inside a manhole, try to minimize the mixing of any outside air with the air in a manhole. Testing should be conducted through the holes in a manhole cover (Figure 9.4) or under the edge of the cover before it is completely removed.

A thorough test should be conducted at all levels in the confined space (from top to bottom of a manhole) before deliberate ventilation is started or anyone is allowed to enter the confined space. Continue testing throughout the entire time the manhole is occupied. Testing must include tests for a shortage of oxygen, explosive gases and toxic gases (hydrogen sulfide and any other harmful gas that might be present).

Manholes and confined spaces should be tested before entry and while working in the area. Wastewater flows and characteristics can change continuously and the atmosphere above the wastewater surface also can change, especially if the confined space is downstream from an industry or hospital. Whenever a manhole or confined space is reentered, be sure to retest the atmosphere if testing has stopped.

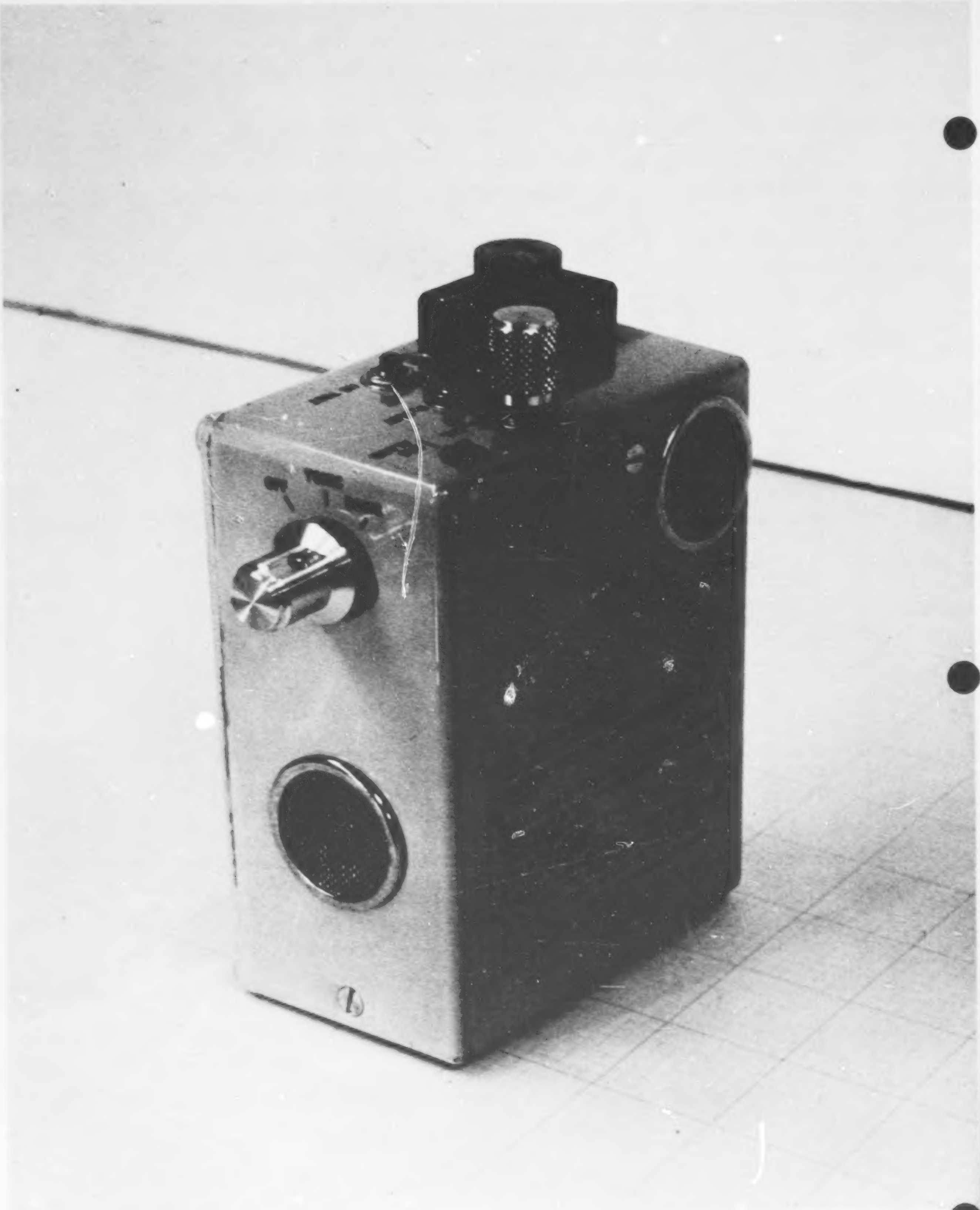


Fig. 9.3. Gas detection device capable of testing for hydrogen sulfide, methane and oxygen

(Courtesy of ENMET Corporation)

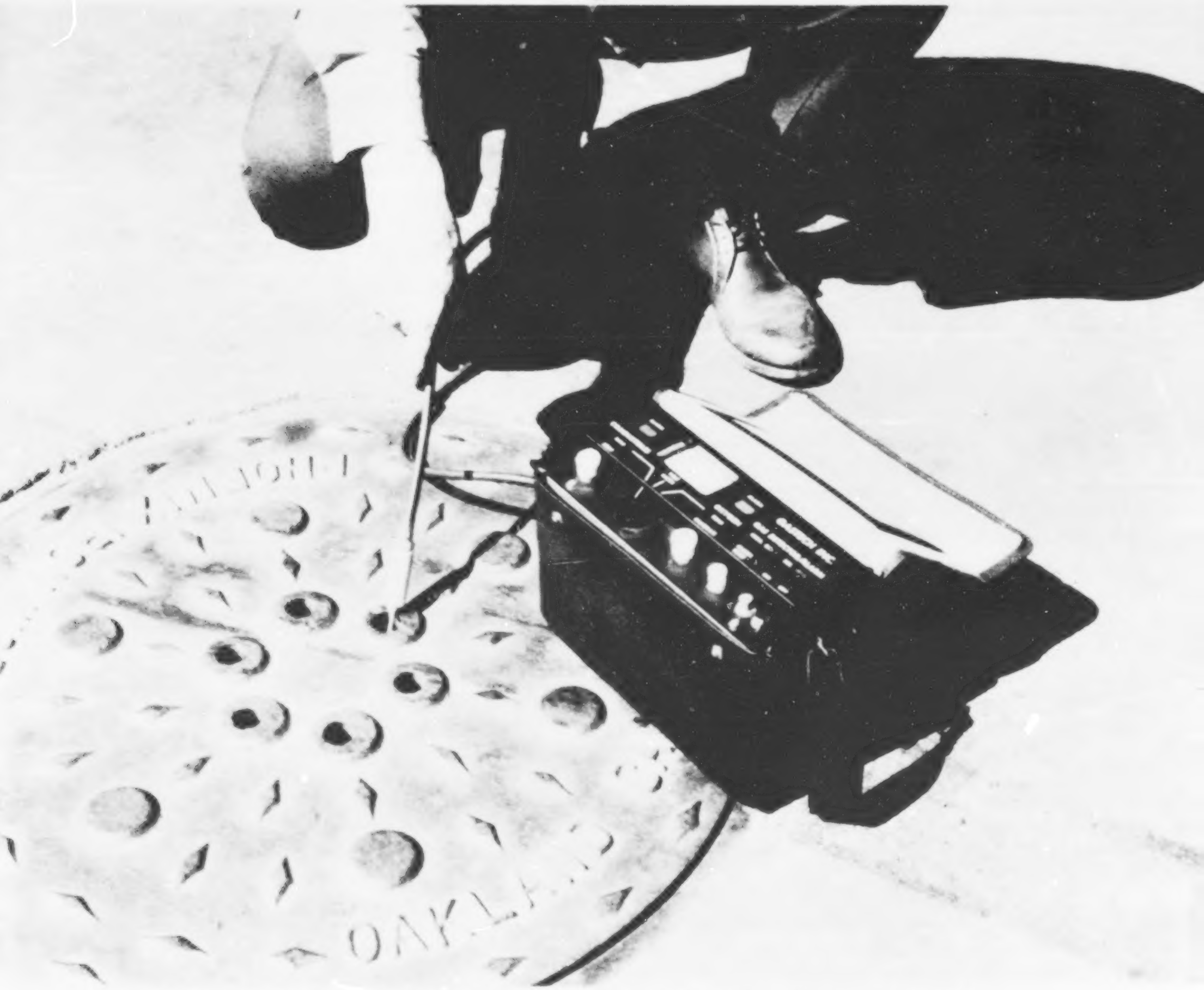


Fig. 9.4. Testing for hazardous gases in a manhole BEFORE removing lid. (Courtesy of Gastech Inc.)

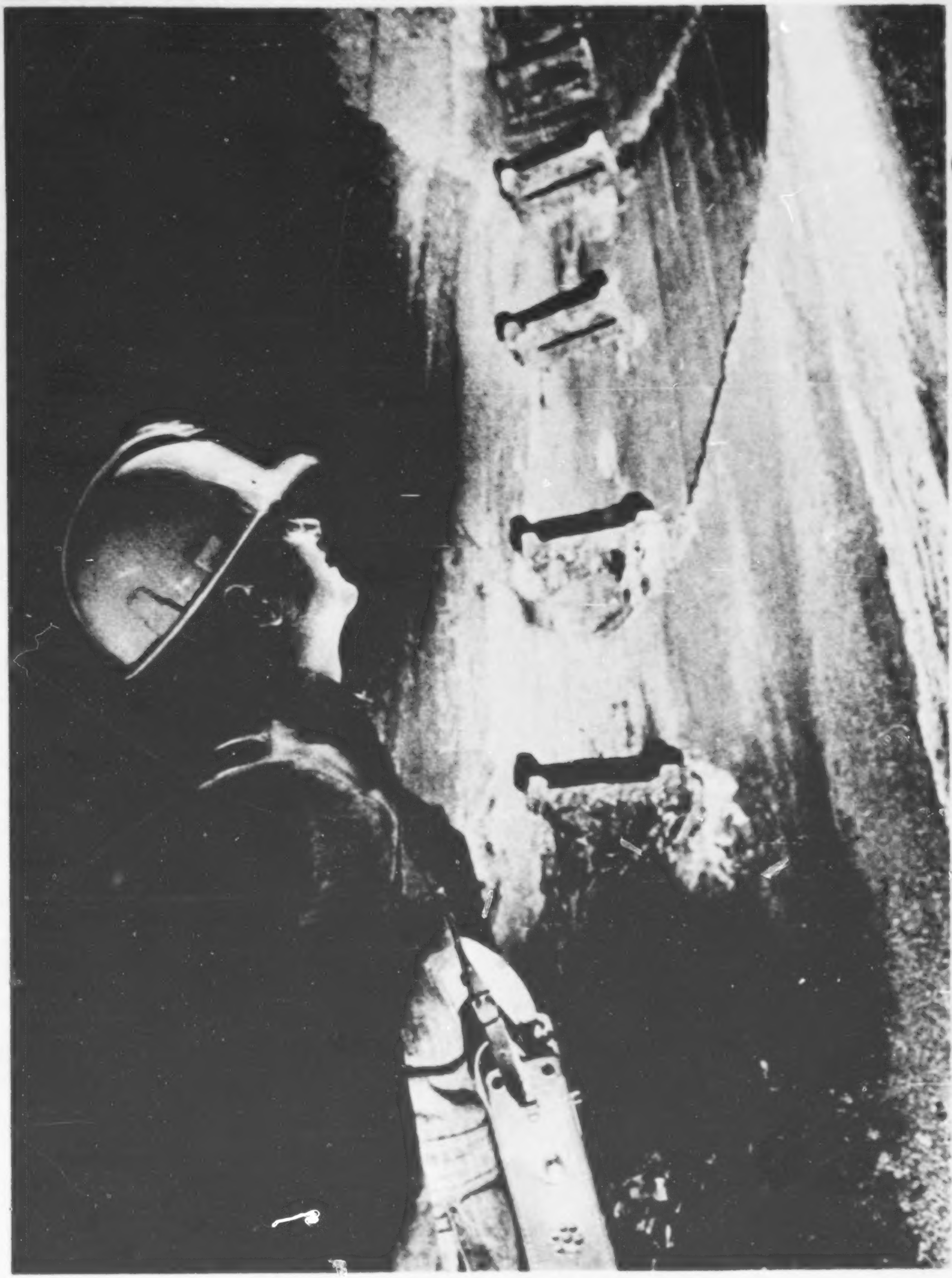


Fig. 9.5. Worker using gas detection device.
(Courtesy of ENMET Corporation)

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QUESTIONS

9.2G Why is an oxygen deficient atmosphere hazardous?

9.2H Why should you attempt to measure the level of oxygen in a manhole before or immediately after the manhole cover is removed?

9.2I What would you do if you were required to work in an oxygen deficient atmosphere?

9.25 Protection Against Hazardous Gases

Adequate ventilation is the best protection against hazardous gases. See Section 9.5, Manholes and Other Confined Spaces for details.

9.26 Summary

Table 9-1 contains a Summary of Common Dangerous Gases. Study this table and especially note the physiological (body) effects and methods of testing for the gases. Technology is developing rapidly in the field of instruments for measuring gases found in sewers. Contact your instrument supplier for the latest proven developments in gas detecting instruments.

QUESTIONS

9.2J How can hydrogen sulfide be detected?

9.2K Prepare a list of dangerous gases encountered in wastewater collection systems and indicate how you would test for each gas.

TABLE 9-1

COMMON DANGEROUS GASES ENCOUNTERED IN WASTEWATER COLLECTION SYSTEMS AND AT WASTEWATER TREATMENT PLANTS[1]

Name of Gas	*Chemical Formulae*	*Specific Gravity of Vapor Density*** *(Air = 1)*	*Explosive Range (% by volume in air)*		*Common Properties (Percentages below are per cent in air by volume)*	*Physiological Effects (Percentages below are per cent in air by volume)*	*Most Common Sources in Sewers*	*Simplest and Cheapest Safe Method of Testing*†
			Lower Limit	*Upper Limit*				
Oxygen (In air)	O_2	1.11	Not flammable		Colorless, odorless, tasteless, non-poisonous gas. Supports combustion.	Normal air contains 20.93% of O_2. Man tolerates down to 12%. Below 5 to 7% likely to be fatal.	Oxygen depletion from poor ventilation and absorption or chemical consumption of available O_2.	Oxygen deficiency indicator.
Gasoline Vapor	C_5H_{12} to C_9H_{20}	3.0 to 4.0	1.3	7.0	Colorless, odor noticeable in 0.03%. Flammable. Explosive.	Anesthetic effects when inhaled. 2.43% rapidly fatal. 1.1% to 2.2% dangerous for even short exposure.	Leaking storage tanks, discharges from garages, and commercial or home dry-cleaning operations.	1. Combustible gas indicator. 2. Oxygen deficiency indicator for concentrations over 0.3%.
Carbon Monoxide	CO	0.97	12.5	74.2	Colorless, odorless, non-irritating, tasteless, Flammable. Explosive.	Hemoglobin of blood has strong affinity for gas causing oxygen starvation. 0.2 to 0.25% causes unconsciousness in 30 minutes.	Manufactured fuel gas.	CO ampoules.
Hydrogen	H_2	0.07	4.0	74.2	Colorless, odorless, tasteless, non-poisonous, flammable. Explosive. Propagates flame rapidly; very dangerous.	Acts mechanically to deprive tissues of oxygen. Does not support life. A simple asphyxiant.	Manufactured fuel gas.	Combustible gas indicator.
Methane	CH_4	0.55	5.0	15.0	Colorless, tasteless, odorless, non-poisonous. Flammable. Explosive.	See hydrogen.	Natural gas, marsh gas, mfg. fuel gas, sewer gas.	1. Combustible gas indicator. 2. Oxygen deficiency indicator.

**Gases with a specific gravity less than 1.0 are lighter than air; those more than 1.0 heavier than air.

†The first method given is the preferable testing procedure.

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1. Reprinted from Water and Sewage Works, August 1953.

Copied from "Manual of Instruction for Sewage Treatment Plant Operators", State of New York.

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TABLE 9-1 (Continued)

COMMON DANGEROUS GASES ENCOUNTERED IN WASTEWATER COLLECTION SYSTEMS AND AT WASTEWATER TREATMENT PLANTS[1]

Name of Gas	Chemical Formulae	Specific Gravity of Vapor Density** (Air = 1)	Explosive Range (% by volume in air)		Common Properties (Percentages below are per cent in air by volume)	Physiological Effects (Percentages below are per cent in air by volume)	Most Common Sources in Sewers	Simplest and Cheapest Safe Method of Testing†
			Lower Limit	Upper Limit				
Hydrogen Sulfide	H_2S	1.19	4.3	46.0	Rotten egg odor in small concentrations but sense of smell rapidly impaired. Odor not evident at high concentrations. Colorless. Flammable. Explosive. Poisonous.	Death in few minutes at 0.2%. Paralyzes respiratory center.	Petroleum fumes, from blasting, sewer gas.	1. H_2S ampoules. 2. 5% by wt. lead acetate solution.
Carbon Dioxide	CO_2	1.53	Not flammable		Colorless, odorless, non-flammable. Not generally present in dangerous amounts unless there is already a deficiency of oxygen.	10% cannot be endured for more than a few minutes. Acts on nerves of respiration.	Issues from carbonaceous strata. Sewer gas.	Oxygen dificiency indicator.
Nitrogen	N_2	0.97	Not flammable		Colorless, tasteless, odorless. Non-flammable. Non-poisonous. Principal constituent of air (about 79%).	See hydrogen.	Issues from some rock strata. Sewer gas.	Oxygen deficiency indicator.
Ethane	C_2H_6	1.05	3.1	15.0	Colorless, tasteless, odorless, non-poisonous. Flammable. Explosive.	See hydrogen.	Natural gas.	Combustible gas indicator.
Chlorine	Cl_2	2.5	Not flammable Not explosive		Greenish yellow gas, or amber color liquid under pressure. Highly irritating and penetrating odor. Highly corrosive in presence of moisture.	Respiratory irritant, irritating to eyes and mucous membranes. 30 ppm causes coughing. 40-60 ppm dangerous in 30 minutes. 1000ppm apt to be fatal in few breaths.	Leaking pipe connections. Overdosage.	Odor, strong ammonia on swab gives off white fumes.

**Gases with a specific gravity less than 1.0 are lighter than air; those more than 1.0 heavier than air.

† The first method given is the preferable testing procedure.

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[1] Reprinted from Water and Sewage Works, August 1953.

Copied from "Manual of Instruction for Sewage Treatment Plant Operators", State of New York.

9.3 DRIVING SAFETY = DEFENSIVE DRIVING

Defensive driving is a mature attitude toward driving. You should always be alert for the great number of drunks, incompetents, new drivers, sleepers, and other hazards that can pop up in your path at any unguarded moment. Always try to drive with a plan for what you would do if someone else drives crazily. Defensive driving is different from legal driving because injury and accident can still occur even though you are driving legally. Defensive driving is careful driving to avoid the accidents, while realizing all the special hazards that exist on the highway regardless of who has the legal right of way. Always maintain a safe stopping distance behind the vehicle in front of you (Figure 9.6).

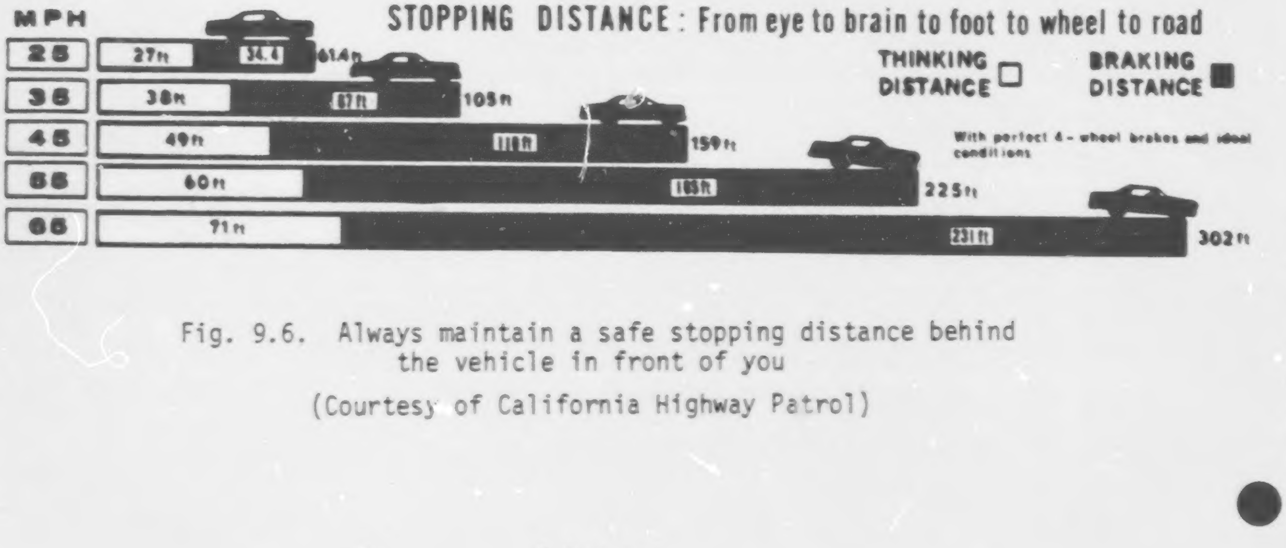

Fig. 9.6. Always maintain a safe stopping distance behind the vehicle in front of you

(Courtesy of California Highway Patrol)

9.31 Driving Safety

Driving safety is especially important to the trained collection system worker.

1. Driving to work can be more hazardous than at work. Driving is still one of the nation's main killers.

2. Careful inspection of your vehicle before leaving the yard or shop should be a daily routine. Before starting inspect operability of horn, headlights, stop lights, trailer lights, safety hitches and chains on trailers, brakes, mirrors, back-up signals, wheel chock (to keep parked vehicles from running away), and be sure all windows are clean.

3. On the job the collection system worker frequently drives a truck larger than a pickup with less than passenger car clearance and visability. This type of vehicle should be equipped with a special side mirror and an alarm that rings a bell when the wheels move backwards (or sound a horn when shifted into reverse). Avoid backing up until you know you can do it safely. A good safety practice is for the passenger to get out and guide the driver when the driver is backing up or driving forward when entering or leaving a work area. Traffic isn't looking for a parked truck to move and work crews often distract drivers.

   Traffic cones placed on all four corners of a vehicle will tell the public, "here is a safe outfit" as well as make the driver notice all sides of the vehicle when gathering up the cones to leave the job site. New hazards such as children or toys can be seen before they are runover. Also look for children in, on, or around vehicles before moving. Many public utilities require the placement of traffic cones for these reasons. Accident records show that "the hitting of stationary objects" is reduced by this simple act.

   Frequently a trailer of some sort with a rod or a compressor has to be pulled to the work site. A tank truck full of water can be especially difficult to handle safely. Driving under these conditions creates additional hazards and requires attention to special vehicle codes to drive legally. In some states, special drivers licenses are required to drive vehicles larger than passenger cars or pickups.

4. The collection system worker must often work in the busy street and sometimes at intersections. The worst traffic hazard is "in town". You should always park the truck with brakes set and roof light flashing in such a position that careless traffic must "plow" into the truck before it can "run over" the crew working in or around a manhole. High warning signs (with blinkers at night) should be placed far enough ahead of the work to provide plenty of time for drivers to slow down gradually.

9.32 Traffic Control

(Also see Chapter 4, Section 4.11, Traffic Safety.)

Safety cones should be placed to first reduce the number of traffic lanes in a multilane road and then direct the traffic safely past the lane blocked for maintenance work.

The use of a well marked and trained flagman or guide car may sometimes be necessary for safe traffic control.

Proper barricades with blinkers should be used both day and night at sights in or near traffic lanes. Required uses are generally carefully spelled out by law and should be determined with co-operation of proper authorities before needed.

Highway Patrol or Police are experts at traffic control and can generally provide training or guidance if necessary and should be consulted if there is any doubt regarding the legality or safety of special work set ups in the street or on the highway. In some cities and states, permits are required to work in streets or highways and route traffic. At night, flares similar to those used by Police will provide a warning to high speed traffic and should be used when legal and needed. A better approach is to have a well lighted work area using quartz iodine lamps mounted on maintenance trucks.

QUESTIONS

9.3A What is defensive driving?

9.3B Where should the truck be parked when working in traffic?

9.3C How can other people be warned that a truck is backing up?

9.3D Why are safety cones placed around a parked vehicle?

9.3E How can traffic be directed around a work site?

9.3F Where can you obtain additional training and guidance for the proper methods to route traffic around a job site?

END OF LESSON 1 OF 3 LESSONS
ON SAFETY FOR THE COLLECTION SYSTEM WORKER

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

(Lesson 1 of 3 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. Why is safety important?
2. How can the poor safety record of collection system workers in the past be improved?
3. Why is the job of a collection system worker hazardous?
4. How can collection system workers protect their health?
5. Why is the collection system worker confronted with gas hazards?
6. How can you protect yourself and your crew from gas hazards?
7. How can you avoid driving accidents?

DISCUSSION & REVIEW

CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

(Lesson 2 of 3 Lessons)

9.4 EXCAVATIONS AND TRENCH SHORING

(Also see Chapter 6, Section 6.2, Shoring.)

Deep excavations (5 feet or deeper) without shoring or with improper shoring have allowed cave-ins that have killed many workers. The great temptation to "short-cut" the possible expense and time-consuming shoring seems to be universal, and the trained collection system worker should be alert to a responsibility to be on the lookout for such hazardous operations.

In addition to watching for your own safety and that of your fellow workers, the collection system worker may need to inspect or advise about collection system construction excavations made by your agency or by contractors working for your agency. The contractor principally interested in gaining a profit is often tempted to save on shoring or other safety requirements. The collection system worker may be the most informed professional, along with the engineer, to re-examine, inspect, and help enforce OSHA[3] safety laws.

9.41 Causes of Cave-Ins

Your knowledge, judgement, and courage play a vital role in the safety of workers and facilities in new construction, as well as regular maintenance. Refer to "as-built" prints for unstable soil conditions along a trench if you must excavate for repairs.

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[3] The Williams-Steiger Occupational Safety & Health Act of 1970 (OSHA) is now the law of the land. The Act does not directly apply to municipalities at present (1976), except in those states which have approved plans and have asserted jurisdiction under Section 18 of the OSHA Act. However, "there's no question about the impact of OSHA since 1970, this law has affected all phases of wastewater treatment plant activity, design, construction, operation and maintenance," said Ben Socewitz, Chairman of Water Pollution Control Federation Safety Committee.

Working in trenches does not have to be dangerous. Newspaper accounts of excavation cave-ins frequently show where someone failed to provide proper protection for the victims. Properly shored trenches do not cave-in. Most accidents resulting in trench sidewall cave-ins result from:

1. Failure to shore, possibly because of a deliberate short-cut to save time or expense.
2. Inadequate shoring because of lack of knowledge or misjudgement of soil stability.
3. Failure of shoring because of unsuspected bank loading caused by traffic or machinery vibration.
4. Inadequate shoring maintenance or replacement after changes occur in the soils surrounding an excavation as a result of construction work or heavy rains.
5. Failure of shoring material.
6. Placement of spoil too near the trench edge.
7. Trench wall undercutting.

9.42 Shoring Requirements

The new OSHA standards are the criteria in any accident litigation, so they apply indirectly to state, county, and municipal employees, if not directly, and they apply directly to all municipal contractors.

Non-emergency excavations of five feet or greater in depth may require permits in some states before work can proceed. Every collection system worker should become as familiar as possible with

OSHA REQUIREMENTS
OSHA

OSHA requirements to protect yourself, your co-workers and your employer. In general, conditions affecting shoring are described in this section, though no standard formula may be practical. Shoring must meet the conditions of each job. Among the considerations required to evaluate the shoring conditions are:

1. Soil Structure. Trenches may be cut through rock which requires little or no support or, at the other extreme, through loose soil with sufficient moisture to cause the soil to flow and produce pressure on shoring. Even rock may be fractured and become sufficiently unstable, when cut, to require some protection for workers in a trench. Sand or back-filled soil usually is very unstable and requires tight sheeting and bracing.

2. Fluctuations in Weather and Moisture Conditions. A trench through frozen ground may be safe while frozen, but may cave-in on thawing. Rainfall, or overflow from a nearby stream, storm drain, or wastewater collection line can add moisture and change soil conditions and shoring requirements.

3. Structures or Sources of Vibration Near Trenches. Such sources impose extra requirements on shoring. Excavating near buildings may disturb foundations and shoring may be required to protect them as well as persons working in the excavation. Nearby traffic and operating machinery may cause vibrations which will cause otherwise stable soil to cave-in. Special shoring requirements are necessary when vehicles or other equipment on the job must travel or operate near the trench.

4. Size and Shape of the Trench. Shoring must be designed according to width and depth of the trench. Need for shoring may be eliminated entirely by opening or sloping the trench walls along the angle of repose.[4]

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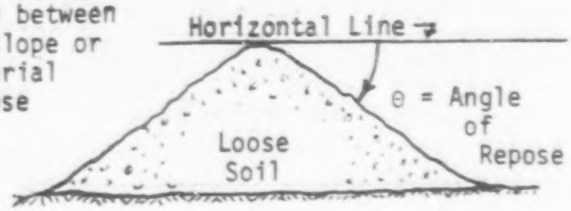
[4] Angle of Repose. The angle between a horizontal line and the slope or surface of unsupported material such as gravel, sand or loose soil. Also called the natural slope.



5. After shoring has been safely and securely installed, do not consider your shoring job completed. CONDITIONS CAN CHANGE. Shoring can lose its effectiveness after a rain, frost, freezing, thawing, earthquake, thunder storm, vehicle or train vibrations, or a broken water main. Whenever a condition changes or something happens that could influence the effectiveness of shoring, be sure to inspect the shoring and verify its ability to prevent cave-ins. Shoring should be inspected at the start of each day.

9.43 Protection of Shoring

Operations in and around the excavation impose special requirements to assure continued protection against cave-ins. When machinery is used for trenching, it should be kept level to prevent undercutting of trench walls. When hoists or buckets are used, precautions are necessary to prevent damage to the bracing. Shoring should keep pace with trench opening, or at least in reaches where crews are working in the trench.

Heavy equipment, such as air compressors and concrete mixers used in conjunction with work in the trench, should not be set on the walls or shoring timbers. They should be located on special vertical supporting timbers in a way which will not cause damage to the shoring.

9.44 Cooperation Between Workers and Supervisor

All work below the ground surface requires the continual watchfulness by workers and supervisors who must cooperate to protect the workers below ground. The protection that shoring provides depends in part on how well it is maintained and adjusted on the job. Attention to these needs can assure safety during the work and completion of another job without injury.

QUESTIONS

9.4A What is the purpose of shoring?

9.4B What causes excavation or trench sidewall cave-ins?

9.4C What is OSHA?

9.4D Can cave-ins be caused by vehicles and equipment operating near a recently excavated trench?

9.4E Why must care be taken when operating equipment near shoring?

9.5 MANHOLES AND OTHER CONFINED SPACES

(Also see Chapter 4, Section 4.1, Traffic and Manhole Safety)

9.51 Types of Hazards

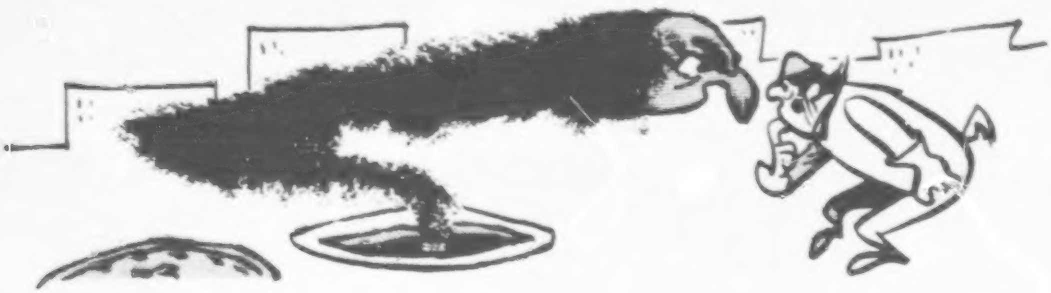
Many hazards are connected with manhole work. These hazards can be eliminated or reduced so that chances for injury are minimal if you are aware of the hazards and how to do your job safely. Hazards which may be encountered and must be recognized include the following:

1. Traffic. Both vehicular and pedestrian traffic may be involved. This causes danger to the public and the workers and requires job site protection by barricades and warning devices.

2. Adverse Atmospheres. The enclosed space may contain flammable, explosive and poisonous gases or a deficiency of oxygen. This requires gas testing before entering and preferably before opening the manhole cover or door to a confined space. Artificial ventilation is always required along with re-testing. See Section 9.2, Gas Hazards, for more information.

3. Physical and Structural Conditions. Difficulty may be encountered when entering a manhole. The rungs leading

to the bottom may be corroded and not strong enough to support a worker. Unless you are certain of the safe condition of manhole rungs, use a portable ladder. The interior space of a manhole often contains dangerous



liquids and is likely to restrict your movement and be damp and dark. These hazards require good inspection, personal protective equipment, good personal hygiene, communication equipment, portable explosion-proof lighting, safety harness with rope, and at least two workers topside.

4. Insects, Spiders, Bugs and Rodents. Even after a manhole has been washed down there still could be problems. Always inspect a manhole for these pests before entering.

A step by step approach to safe manhole or other confined space entry is listed below as a rigid safety policy and might be adapted to the safety needs of any municipality.

9.52 Safety Procedures

Prior to leaving maintenance yard or depot, all specified safety equipment, testing devices and tools necessary for the work should be with the vehicles going to the job site. The workers must be familiar with each piece of equipment and its use. The location of this equipment must be at a standard, well defined location which is known to all the crews. At the job site it is the responsibility of the lead worker of the crew to have the vehicle positioned to prevent any occurrence of injury from adjacent or on-coming traffic or from exhaust fumes from the vehicle. Upon arrival immediately position the work vehicle and properly place traffic control cones and warning flags. Once this has been done, the lead worker must discuss what jobs will be performed by each crew member and in what sequence.

Test for atmospheric conditions in the manhole (also see Section 9.24, Detection of Hazardous Gases). Remove the manhole lid using a suitable hook and place the lid at a safe distance away from the work area and traffic. Care should be exercised that there are no sparks, smoking or open flames near the manhole opening. Tests for the presence of combustible or toxic gases shall be made with an approved device prior to work or entering a confined space (preferably before removing the lid). All crews must be equipped with a combustible gas-oxygen deficiency indicator and hydrogen sulfide detector (Figure 9.3) which shall be used to determine the concentrations of hazardous gases. The test equipment for combustible gas, toxic gas, and oxygen deficient atmospheres shall be lowered with a line to a point as near the bottom as feasible. This gas test equipment should be provided with audio and visual alarms. Operating safety ranges of the test equipment will be posted and attached to the lid of each instrument. In addition to the test equipment, there also will be standardization tests to calibrate the test equipment. The test equipment must be calibrated prior to use by zeroing the instruments in a known safe atmosphere. The testing devices may require recalibration if they are unduly jostled in transit. Tests for combustible or toxic gases are to be conducted in the following order:

1. Explosimeter.

   Test throughout depth of confined space. An indicator reading of .0 to .2 (0 to 20% of lower explosive limit) indicates that any explosive gases present probably are not within the explosive range. .20 to 1.00 (20% to 100% of lower explosive limit) indicates a dangerous situation - combustible gases are present in hazardous concentrations. 1.00 and above (100% of lower explosive limit) indicates that an explosion is possible at any moment.

WARNING

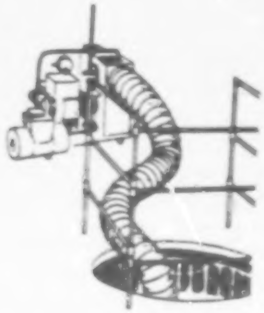
When a person is working in an acceptable atmosphere in a confined space, there shall be one worker at a standby position and one other worker within sight and call of the standby worker.

2. Combustible gas-oxygen deficiency test equipment or sample tube will be suspended in the work area by means of a line.

3. A hydrogen sulfide instrument or detector badge will be worn by the worker entering the confined space. Be sure to wear the badge where you can see if it turns color.

If the audio or visual alarm is activated by an oxygen deficiency or an explosive condition or if the hydrogen sulfide instrument alarm sounds or the badge discolors, the worker in the confined space must leave immediately.

Confined spaces should be ventilated before and during work periods (Figure 9.7). If tests indicate the atmosphere in the space is safe for breathing, realize that conditions can change rapidly. Confined spaces should be ventilated whenever someone is in the enclosure. To determine the capacity of a blower or ventilator, you have to know the volume of the confined space and the desired or required number of air changes per hour. At least four complete changes of air per hour is a minimum,and more changes are necessary if there is any chance of a hazardous gas entering the atmosphere. Local regulations may require more frequent air changes. The greater the chance the greater the number of changes of air per hour are required.



NOTE: Air inlet should be at least two feet above the street level so street trash will not be picked up by the flowing air.

Fig. 9.7. Ventilation of a manhole

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EXAMPLE

What capacity blower (CFM) is required to ventilate a manhole 48 inches in diameter and 22-feet deep with 15 air changes per hour or one air change every 4 minutes?

KNOWN			UNKNOWN
1. MH Diameter, in	=	48 in	Blower Capacity, CFM
2. MH Depth, ft	=	22 ft	
3. Air Change, min	=	4 min	

Determine volume of manhole. Area = $\frac{\pi}{4}$ (Diameter, ft)^2

$$\text{MH Volume, cu ft} = (\text{Area, sq ft})(\text{Depth, ft})$$

$$= \frac{\pi}{4}(4\text{ ft})^2(22\text{ ft})$$

$$= 276.5\text{ cu ft}$$

Calculate blower capacity.

$$\text{Blower Capacity, CFM} = \frac{\text{MH Volume, cu ft}}{\text{Air Change, min}}$$

$$= \frac{276.5\text{ cu ft}}{4\text{ min}}$$

$$= 69\text{ CFM}$$

If after testing and ventilating the confined space, the test equipment still shows the atmosphere to be hazardous, contact your work station or supervisor immediately. Two (preferably three) approved self-contained breathing units[5] must be brought to the work site

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[5] A slide-tape series on the use of self-contained breathing equipment is available from the National Fire Prevention Association Publication Sales Department, 470 Atlantic Avenue, Boston, Mass. 02210. Cost, $35.00. Be sure to specify the manufacturer of your equipment. Also contact the manufacturer of your self-contained breathing equipment for training materials on how to use their equipment.

(if not carried on the truck with the crew) (Figures 9.8 and 9.9). A maintenance truck equipped with large cylinders containing air for breathing can supply a gas mask through proper hose and connectors for a longer time than a self-contained air mask and also be less bulky for workers in confined spaces. Some trucks are equipped with compressors and hose masks. The worker entering the manhole must wear an approved self-contained breathing unit in addition to the safety harness. There also shall be another worker equally equipped in a standby safety position as well as one other person within sight and call of the standby worker.

NOTE: This manpower requirement applies only to hazardous atmospheres caused by concentrations of hydrogen sulfide, other toxic gases, or an insufficient amount of oxygen. Under almost no circumstance is a worker to enter into a confined space deemed hazardous because of combustible gas mixtures. The standby worker may perform any duties including the operating of blowers if they are electrically driven. If, however, the blowers are gasoline engine driven, then an additional worker will be assigned to the blowers and will have no other duties. The standby worker should observe the worker in the manhole to monitor the worker's alertness. Under emergency conditions, pull the worker needing help out of the confined space by the safety harness. Once the worker is clear, first aid should start immediately if needed. While first aid is being applied, the other worker on the crew should be obtaining needed professional assistance.

Safety regulations require two workers topside whenever one worker enters a manhole or confined space. Two workers topside are considered essential if the worker in the confined space must be rescued. Industry is currently developing equipment to replace the need for the third worker on a crew. A promising device is a heavy duty tripod installed over a manhole before the manhole is entered. If properly designed, one worker could rescue an injured or unconscious worker in a harness belt from a manhole.

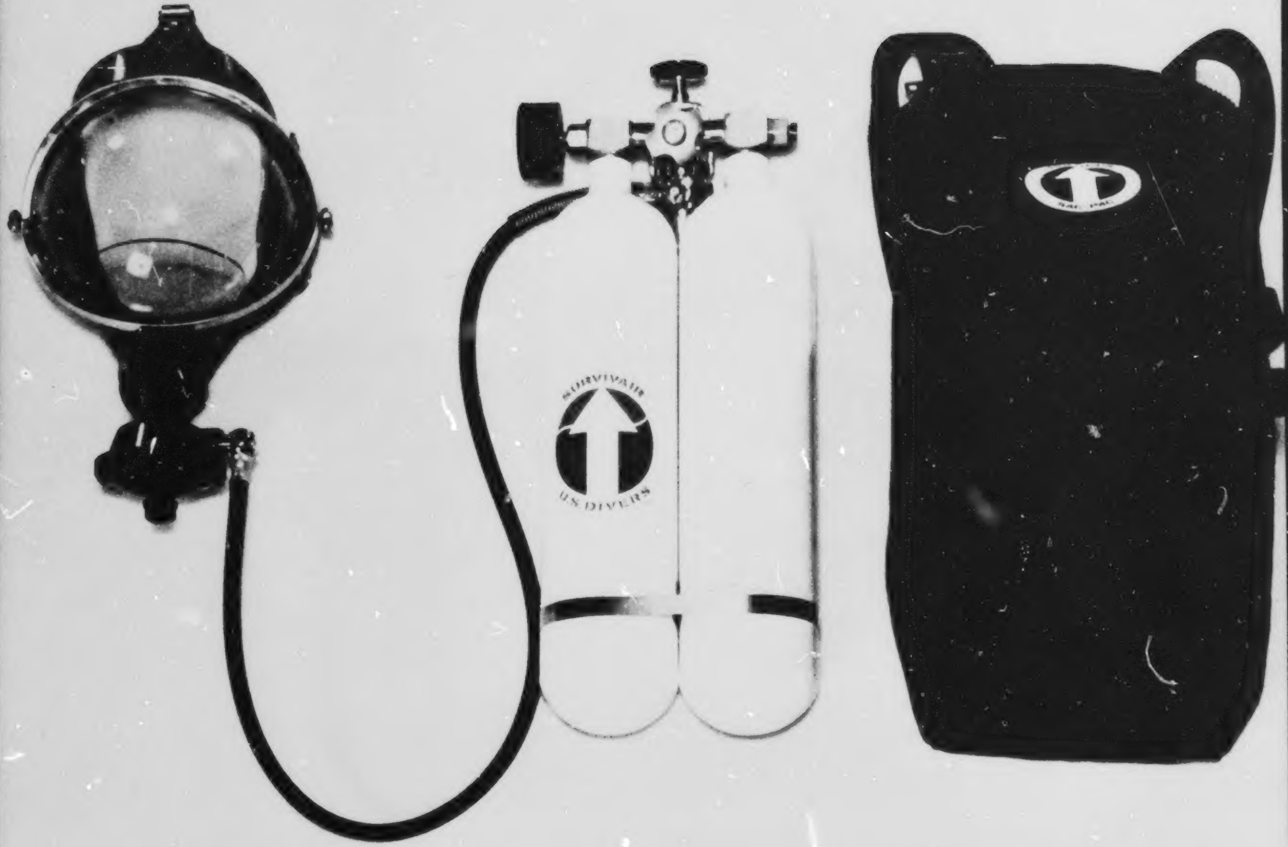
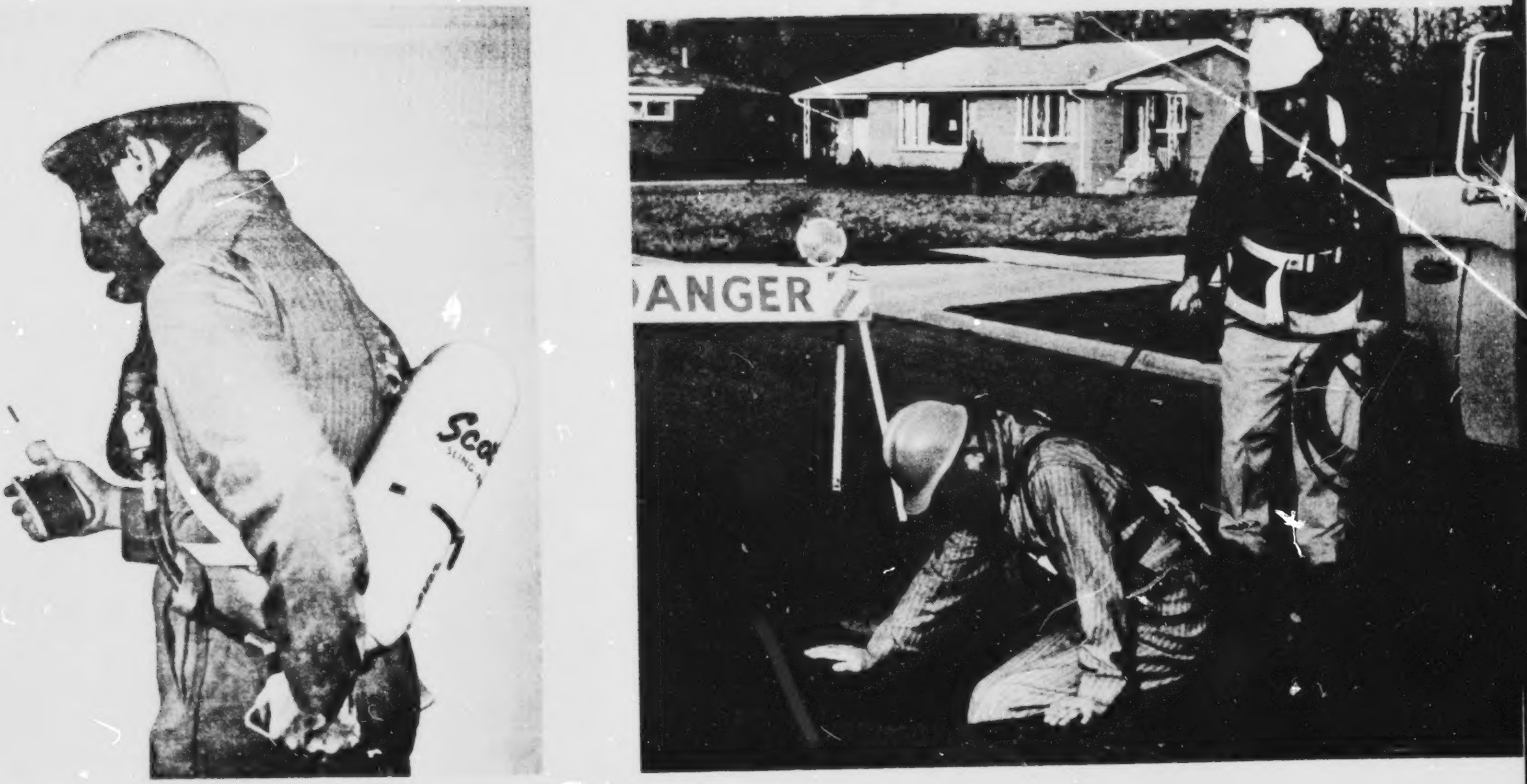

SURVIVAIR
U.S. DIVERS
SAC-PAC

Fig. 9.8. Self-contained breathing apparatus
(Courtesy of Survivair)



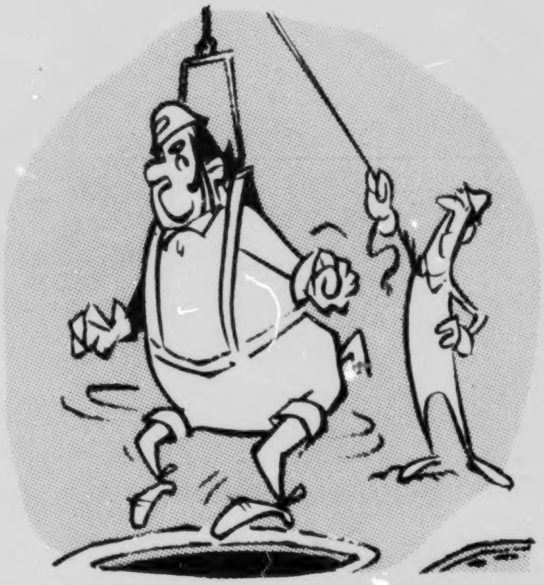
Self-contained

Air from cylinders

Fig. 9.9. Air masks
(Courtesy of Scott Aviation, A Division of A-T-O Inc., Lancaster, New York)

9.53 Safety Harness (Figure 9.10)

Never attempt to do a job unless you have sufficient help and equipment. The safety harness is possibly the most universal piece of safety equipment for a collection system worker. After all tests and precautions, entry into underground enclosures, especially manholes, should be made only with an approved and well-adjusted safety harness and with sufficiently trained help to lift you out safely. If an emergency should arise, this provides the "belt and suspenders" type of protection needed for truly safe maintenance work.



Like a seat belt in an auto, the safety harness may help turn a potentially serious accident into a safe rescue. To insure a safe rescue, a well trained worker must always be within sight and voice range of the worker in the harness with an additional worker near enough to be quickly called to help lift a victim out of a manhole or other confined space. Inspect the safety harness and line regularly for signs of deterioration. Discard any defective equipment.

9.54 Summary of Manhole Safety Steps

1. Park trucks and vehicles to protect working area from traffic and contractor's equipment.
2. Calibrate testing instruments. Test manhole and carefully remove cover from confined space and position it safely away from working area and traffic.

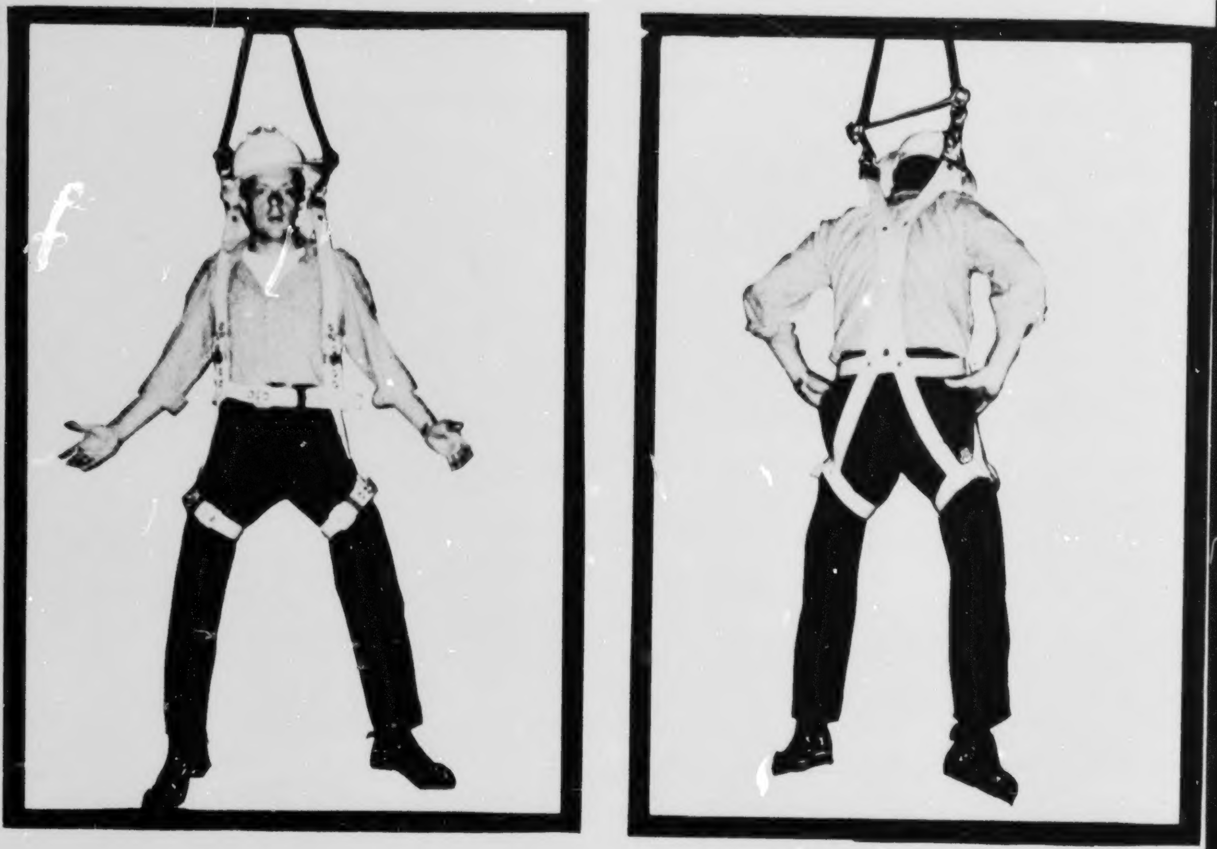


Fig. 9.10. Safety harness

(Courtesy of Miller Equipment Division,
ESB Incorporated, Franklin, Pennsylvania)

3. Again test the atmosphere for the following: Explosive mixtures of gas, hydrogen sulfide gas, and oxygen-deficient atmosphere.

4. Open manholes upstream and downstream from the working manhole to encourage natural ventilation. Be sure these manholes are properly barricaded.

5. Set portable blower in operation a minimum of 20 minutes in the work area prior to permitting a worker to enter a confined space. Position outlet of exhaust tube at bottom of the confined space.

6. Retest as outlined in item "3" above (if continuous monitoring instruments are not being used).

7. Worker entering confined space must wear a hard hat and safety harness. The hydrogen sulfide combustible gas, and oxygen deficiency test equipment will be in the confined space and operated continuously.

8. Work in confined spaces is to be done in short periods of time;and upon any indication of a feeling of nausea or loss of alertness, the worker is to get into the open air as soon as possible.

9. Two workers must be above the ground when a worker is working in a confined space or manhole. One worker must be over the manhole and the other must be within calling distance of the manhole. The only exception is the possible use of an approved tripod and lifting device.

10. Effect rescue operations using the attached safety harness from outside confined space whenever possible.

11. If assistance is required, use your radio equipment or nearest phone to notify your supervisor or radio dispatcher. Specify that "This is an emergency and assistance is required," requesting type of service required and clearly giving exact location.

QUESTIONS

9.5A What kinds of hazards may be encountered when working in and around manholes?

9.5B List the order for testing for combustible or toxic gases.

9.5C What do you do if the atmosphere in a confined space is still hazardous from a toxic gas or an oxygen deficiency after ventilation?

9.5D Even with a self-contained breathing apparatus, you should never enter a confined space deemed hazardous because of combustible gas mixtures. True or False?

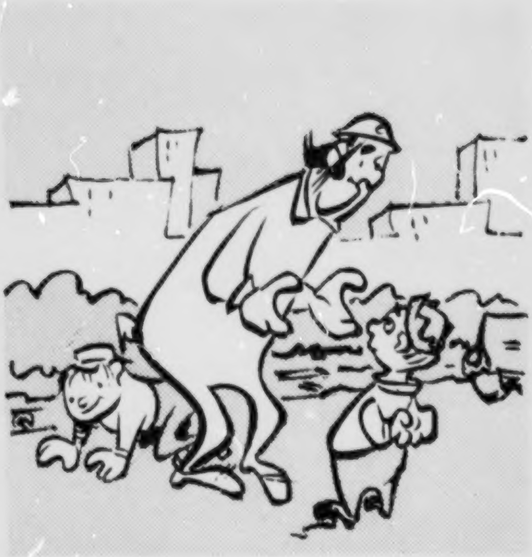
9.5E How long should a portable blower operate in a work area prior to permitting a worker to enter a confined space?

9.5F At the first signs of what kinds of feeling should a worker immediately leave a confined space and get into the open air as soon as possible?

9.6 SAFETY ON THE JOB

Throughout this manual we have tried to stress the importance of using safe procedures to do every job. Previous sections in this chapter have stressed the safety hazards confronting wastewater collection system workers every day. You must always be on the lookout for potential hazards such as infection and infectious diseases, gas hazards, traffic, driving, excavations and confined spaces. This section discusses additional safety hazards you should be aware of on specific jobs, including construction, inspection, pipeline cleaning, and lift station operation and maintenance.

9.61 Construction



Be on the alert for children at all times. They are attracted to a construction or repair site, especially if there is a hole in the ground, such as a ditch or open manhole. Hazards to children include both construction and regular traffic and falling into excavations. Their presence can hinder the work of the repair or construction crew.

In most cases you will lose less time if a friendly crew member will take a few minutes to talk to the children. This crew member should explain to them what the crew is doing, why the work is being done, answer their questions, and describe the seriousness of accidents that could happen if they get too close to the work area. An area that the children must not enter for their safety should be designated, as well as an area where they can safely watch the work may help to keep them out of trouble. Someone should be assigned to be sure the children stay in their designated area.

Watch out for traffic around construction sites. Drivers of passing cars often watch construction activities rather than the road. Persons operating construction equipment may be too busy to look out for workers and inspectors. During hot weather, don't look for shade under or around construction equipment.

Always wear a hard hat to protect your head from injuries.

Drilling and blasting of rock are a hazardous operation and require the services of specialists.

Before working in a trench or excavation, be sure the shoring is properly installed and secure. Do not be hesitant to recheck the shoring for secureness or take the time to place a ladder in a trench for entry or exit. No one wants to be buried in a trench or to have to dig out a fellow worker from a cave-in.

Remove shoring in a slow and safe manner.

Always be on the lookout for underground utilities, especially electrical or gas lines.

Never operate a crane or similar equipment near overhead electrical lines because of the danger of electrocution if equipment should come in contact with the power lines. Ask the power company to shut off power if such work cannot be avoided.

9.62 Inspection

Inspectors must always be safety conscious, whether inspecting new or old wastewater collection systems. Never inspect confined spaces without testing the atmosphere, adequate ventilation and help standing by in case of an emergency.

Stay clear of pipe plugs when a pipe is being air tested for leaks.

If you observe an unsafe condition or act, do not hesitate to notify the workers and stop the work until the condition is corrected or protected and the workers know the safe procedure. Always record the observation of unsafe conditions or acts, who was notified, and the action taken.

9.63 Sewer Cleaning

When cleaning sewers, you must consider the safety of your fellow workers and people living near the work site as well as yourself. Analyze every cleaning job and take all possible precautions to avoid flooding someone's basement or home.

Traffic must be safely routed around the job site. Use barricades, signs, safety cones, flashing lights and flagmen as necessary.

Before entering a manhole or confined space, test for gases found in sewers, provide adequate ventilation, and wear proper safety equipment.

When using rodding equipment, never handle a rod under tension. Treat twisted rods very carefully. They are very dangerous.

9.64 Lift Stations

Safety precautions discussed in Section 9.5, Manholes and Other Confined Spaces, are very important for safe work inside lift stations.

Always be aware of the possibility of gases found in sewers being present.

Do not touch electrical systems or controls unless you are an expert. If you are qualified and authorized, use caution when operating or maintaining electrical controls, circuits and equipment. Operate only those switches and electrical controls installed for the purpose of your job. Do not open or work inside electrical cabinets or switch boxes unless you are authorized and a qualified electrician.

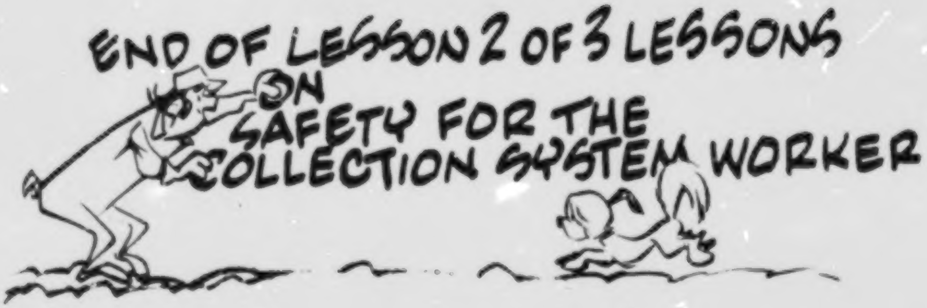
Always be sure you have properly secured an unattended lift station when you leave. This procedure is necessary to prevent injury to a neighborhood child and possible vandalism to the station. Both of these problems can be very costly to your employer if proper precautions are not taken.

QUESTIONS

9.6A List at least five safety hazards around construction sites.

9.6B What are the differences in safety hazards an inspector must watch out for between inspecting old and new wastewater collection systems?

9.6C What precautions must be taken when cleaning sewers?


END OF LESSON 2 OF 3 LESSONS
ON
SAFETY FOR THE
COLLECTION SYSTEM WORKER

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

(Lesson 2 of 3 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

8. Why have deep excavations killed so many workers?
9. How can you as a collection system worker protect yourself and your fellow workers from cave-ins?
10. What kinds of hazards are encountered by collection system workers in manholes?
11. What precautions would you take before entering a manhole?
12. What would you do if you discovered an explosive atmosphere in a manhole?
13. What kinds of hazards exist for children around a job site?
14. What would you do if you were an inspector on a construction job and observed both an unsafe condition and an unsafe act?

WHY • HOW • WHERE • WHEN
WHAT • WHY • WHERE
WHEN • WHY
WHERE • HOW
WHO • WHERE •
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CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

(Lesson 3 of 3 Lessons)

9.7 ADDITIONAL JOB HAZARDS

9.71 Radiological

The newest hazard to collection system workers results from the increasing use of radioactive isotopes in hospitals, research labs and various industries. Inspect your wastewater collection system service area for the possible use of these materials. If a discharger of radioactive substances is connected to your sewers, arrange for the discharger or an appropriate public agency to inspect the discharger for safety precautions and the radioactive substances for safe levels. The discharger will usually cooperate with monitoring this type of waste and notify you whenever a potential hazard exists. Radioactive wastes can be monitored with a Geiger Counter or a ionization-chamber type of lab instrument that measures the level of radioactivity.

9.72 Electrical

(Also see Chapter 8, Section 8.2, Electrical Equipment Maintenance.)

Electric shock frequently causes serious injury, especially where the hazard of a ground and moisture are present. Do not attempt to repair electrical equipment unless you know for certain what you are doing and are authorized to do this type of work.

Safety locks and tags must be placed on all electrical circuits or equipment whenever it is out of service for repair. Tags must indicate date of lock out and signature of person responsible for lock out. In some cases electrical equipment should be kept locked to all but qualified and authorized electrical workers. Of particular hazard to collection system workers when involved with any street excavation is the ever present danger of contacting buried electrical supply lines (especially with increased demands for electrical lines to be placed underground). No excavation should be attempted in public right of ways without checking with the proper agencies and location maps of all underground utilities.

9.73 Noise

Loud noises from gas engines, air hammers, and other equipment can cause permanent ear damage. When noises exceed 85 dB(A),[6] OSHA requires that workers be shielded or protected from the source. Collection system workers must wear the proper ear protection whenever working in too noisy an area for any length of time. Noise levels can be measured with meters. If the noise hurts your ears or makes you feel uncomfortable, protect your ears.

The start of hearing impairment begins at 75 decibels (dB(A)) and at 90 dB(A), there is a 10 to 20 percent hearing impairment if workers are not protected from the noise.[7] The U. S. Environmental Protection Agency has adopted regulations that require all new portable air compressors built in 1978 to produce an average sound level of 76 dB(A) or less when measured at a distance of 23 feet.[8]

QUESTIONS

9.7A List three additional job hazards to collection system workers.

9.7B Where do radioactive isotopes come from that get into wastewater sewers?

9.7C Electrical shock can occur under what kinds of conditions?

9.7D What safety precautions should be taken when electrical circuits and equipment are taken out of service for repair?

9.7E What sources of noises can cause permanent ear damage?

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[6] dB(A). A measure of loudness that corresponds to the way our ears hear sound.

[7] Environmental Science and Technology, Vol. 8, No. 12, Nov. 1974, p. 963.

[8] Federal Register, January 14, 1976.

9.8 SAFETY ACTION

9.81 Fire Fighting

Everyone must know what to do in case of a fire. If proper action is taken quickly, fires are less likely to cause damage and injury. In order to put a fire out promptly, the proper type of fire extinguisher must be used.

Fires are classified into four categories depending on the material causing the fire.

Class	Material
A	Ordinary combustibles such as wood, paper, cloth or trash.
B	Flammable liquids such as gas, oil, grease or paint.
C	Live electricity such as a short circuit.
D	Metals such as magnesium or sodium.

Use water only on Class A fires. Never direct a stream of water on flammable liquids, electrical fires or metals. Most fire extinguishers are fairly effective on ordinary combustibles. Flammable liquids are fought with a loaded stream vaporizing liquid, foam, carbon dioxide (CO_2) and dry chemical extinguishers. Use only carbon dioxide and dry chemical extinguishers on electrical fires. You could become electrocuted if you tried to spray water on an electrical fire. If possible, turn off power to an electrical fire. Carbon dioxide can be used to put out a metal fire. Never use carbon tetrachloride because the fumes are extremely toxic and when used on hot electrical fires, phosgene (a toxic war gas) can be produced.

Fire extinguishers should be conspicuously located with signs or lights nearby to assist in their location. Everyone should know the type of fire they should be used on and their proper use.

All fire fighting equipment and extinguishers should be inspected on a regular basis such as every 3 or 6 months and after each use. All extinguishers should be refilled promptly after use.

All exits from pump stations and other buildings should be clearly marked. Flammable storage areas must be marked with signs and no smoking allowed.

The phone number of the local fire department should be posted in an obvious location by every phone.

The best way to fight fires is to prevent them from occurring. Fires can be prevented by careful extinguishing of cigarettes and good housekeeping of combustibles, flammable liquids and electrical equipment and circuits.[9]

9.82 First Aid

First aid training is an important safety skill for every collection system worker. The skills you learn could help yourself, your fellow workers or even your family and friends. Excellent first aid courses are often presented by local chapters of the American Red Cross. All crew leaders and supervisors should complete the Red Cross' Basic First Aid Course.

The following material, "What Everyone Should Know About First Aid," is provided by the Channing L. Bete Company, Inc., Greenfield, Massachusetts.

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[9] A slide-tape series on the use of fire extinguishers is available from National Fire Prevention Association Publication Sales Department, 470 Atlantic Avenue, Boston, Mass. 02210. Utilize Fire Extinguishers, No. ASK-4A, Price, $35.00.

PAGE 9-55 "What Everyone Should Know About Safety" removed prior to being shipped to EDRS for filming due to copyright restrictions.

QUESTIONS

9.8A What different types of materials can cause different types or classes of fires?

9.8B How can each class or type of fire be extinguished?

9.8C How often should fire fighting equipment and extinguishers be inspected?

9.8D What would you do if a fellow worker badly cut his hand?

9.8E What would you do if you broke your arm?

9.9 SAFETY TRAINING PROGRAMS

Effective safety programs rely on many techniques to help workers recognize hazards and learn safe procedures. These safety programs can range from highly organized meetings to tail gate safety sessions to informal get togethers or bull sessions. Safety programs of all types have proven very effective when the following conditions are met:

1. Basic safety concepts and practices are thoroughly understood by all.

2. Everyone participates and accepts their personal responsibilities for safety and that of their fellow workers (participation at all levels is absolutely essential to the continued success of any safety program).

3. Adequate safety equipment is available and its capabilities thoroughly understood. Crews must regularly review and drill in the actual use of the equipment under emergency and hazardous conditions.

4. Everyone realizes that safety is a continuing learning and re-learning process - a way of life that must become part of your regular habits.

5. Accidents are disected, studied, and thoroughly reviewed with the attitude that "they are caused and don't just happen" with the intent that every reasonable step will be taken to reduce the chance of an accident happening again to as near zero as is practical.

6. Every detail of work is a subject for discussion to the extent it will improve safety.

7. Workers realize they should stop anyone performing an unsafe act and remind the person that they are not following safe procedures, why, and how the job can be done safely.

8. Ability. Before starting a job, assure yourself you can do the job without injury. If you are assigned work you are not qualified to perform, call this problem to the attention of your supervisor.

9. Understanding. Before starting a job, thoroughly understand the work to be done, your job and the safety rules that apply. Tail gate safety sessions or pre-job discussions will help promote safe operations.

10. Management actively supports the safety training program and demands that safe equipment and procedures be used at all times.

9.91 Safety Meetings

Safety meetings are scheduled sessions to discuss a specific situation or problem. An expert may be asked to lecture and show slides or movies on how to do the following:

1. Do a specific job safely.
2. Use a particular machine safely.
3. Avoid a certain type of accident.
4. Test for gases found in sewers.
5. Shore up trenches.

To plan a safety meeting, identify a topic or topics that should be discussed. These topics could be safety hazards that have caused injuries in the past or could cause injuries in the future. Another possibility could be new job assignments or responsibilities that require additional training.

If necessary, invite an outside expert to speak who can command the respect and attention of the workers. This person may have had the opportunity to talk on this subject several times and can do so very effectively with little preparation. If you have trouble finding someone to talk on a particular problem that is not familiar with your specific hazards, have an interested worker in your organization prepare a discussion with supervisory help and invite other workers to contribute too.

9.92 Tail Gate Safety Sessions

Tail gate safety sessions are so called because the session consists of a small group of workers gathered around the tail gate of a pickup or truck to discuss safety. These sessions are usually held near the work site and new and old safety hazards and safer approaches or techniques to deal with the problems of the day or week are discussed. The amount or degree of organization or formality of the sessions depends on the types of safety problems and what you think is the most effective way of educating your crew.

9.921 Formal Tail Gate Sessions

To start a program of formal "Tail Gate Sessions", develop a plan or program. The length of session should last from 10 to 20 minutes, depending on the topic and the workers. Try to schedule a talk for around 10 minutes that does the following:

1. Clearly states the safety problem.
2. Outlines and demonstrates safe procedures.
3. Relates topic to actual jobs workers must perform regularly.

After the talk, open up the meeting to questions and try to encourage questions and solutions from the workers at the meeting. Listen carefully to what each person says and try to understand what they are saying. If they have trouble expressing themselves, ask more questions. Be sure everyone understands the problem and procedures discussed.

Typical topics that could be discussed at a tail gate safety meeting include:

1. Measuring and monitoring atmospheres in manholes.
2. Ventilation of confined spaces.
3. Shoring.
4. Tool safety.
5. Manhole entry.
6. Traffic control.
7. Use of specific pieces of safety equipment.

Ask your workers if they have topics they would like to discuss. Periodically repeat discussions of important topics.

9.922 Informal Tail Gate Sessions

To plan an informal "Tail Gate Session", simply pick a good time and place to talk where you won't be distracted. The discussion is an informal chat between the crew leader and the work crew. Sessions usually last from 5 to 15 minutes, depending on interest and discussions by the workers.

Try to make the "meeting" go like a general bull session. Discuss simple topics such as use of a claw hammer, chisel, safety glasses, or hard hats.

Another idea is to announce that "school is opening next week. Pay attention to your driving. Watch out for children early in the morning because it is still a little dark when we leave the yard. Remember how you rode your bike to school? Be alert. Be especially careful when working in the south area and you have to drive by Washington Elementary School."

Usually one of the crew members will enter into the discussion. This worker might comment on an experience or give advice to other crew members. These meetings can be used as refreshers or reminders of safe practices already known, but easily forgotten, overlooked, or skipped to get the job done in a hurry. Topics discussed can include how to coil a rope or has anybody looked at the safety harness lately and inspected it for wear.

Other topics might include:

1. Who sharpened this chisel last? How come the mushroom on the head wasn't ground down?

2. Look at that safety line - it has a knot in the middle of it.

3. Hey Joe! When you were picking up the safety cones today, that truck just about got you at the last one. Can't we start picking them up from the other end of the string? What do you think Sam? Was that truck too close to Joe?

4. Has anyone examined the contents of the first aid kit lately?

Topics should be simple and refer to subjects that the crew is involved in every day or a new or special job that the crew has been assigned. Formal or informal tail gate safety sessions do not replace formal safety meetings.

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9.923 Scheduling Tail Gate Safety Sessions

Tail gate safety meetings should be on a regular basis and at least once a week. Regular meetings provide workers with the feeling that the meetings are a regular part of their job, and an essential and valuable part. Hold the meetings at the beginning of a shift, or right after lunch, or after a break. Perhaps the best time is at the beginning of a shift, when everyone is alert. Try to limit each meeting to between 5 and 10 minutes. If discussion gets hot and heavy - which is good in a way - continue it at the next meeting. Actually tail gate safety sessions can start at any time. Whenever a supervisor sees an unsafe procedure -- stop work now and discuss what could happen, how it could be avoided, and how it should be done properly.

9.93 Safety Summary

All types of safety programs are helpful. If variety is the spice of life, let variety add spice to your safety program. Informal tail gate safety sessions do not replace formal safety meetings or vice versa. Every type of safety meeting can help you develop a very effective safety program.

QUESTIONS

9.9A What types of meetings may be used for safety training programs?

9.9B What factors have to be considered to have an effective safety meeting?

9.9C What is a tail gate safety session?

9.9D What kinds of topics should be covered in any type of safety meeting?

9.9E What do you think is the key or secret to a good safety meeting of any type?

9.10 RECORDS

Unfortunately accidents do happen in spite of all of our efforts. To prevent similar accidents from happening in the future, an "Accident Report" should be completed as soon as possible after an accident. Figure 9.11 is an "Accident Report" suggested by Mr. Carl M. Schwing, Director, Middle Atlantic Applied Technology Institute, Charles County Community College, La Plata, Maryland 20646. Figure 9.12 is another example of an accident report.

9.11 ADDITIONAL READING

1. An excellent source of safety information is the:

   Water Pollution Control Federation
   2626 Pennsylvania Avenue, NW
   Washington, D.C. 20037

   Important WPCF publications include:

   a. Safety in Wastewater Works, Manual of Practice (MOP) No. 1.
   b. Sewer Maintenance, MOP 7.
   c. Wastewater Wisdom Talks
      1) Introduction to "Wastewater Wisdom Talks."
      2) Jobsite Protection.
      3) Personal Hygiene.
      4) Trench Shoring.
   d. Why Every Pollution Control System Needs a Safety Program.

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ACCIDENT REPORT

Date of Report ________________________

Person Reporting ________________Name of Injured Person __________

Check one: First Aid Injury ______ Disabling Injury _____________

Check one: Person Injured Employee _______ Visitor _____________

Occupation of Person Injured ____________________________________

Age _______ Sex _______ Date and Time of Injury _________________

DESCRIPTION OF ACCIDENT

1. Where did accident occur? (Which part of plant?)
2. What did injured person do to cause accident? (Was person wearing protection equipment? Was person using protective equipment? Explain gas detectors -- lead acetate, ampoules, etc.)
3. Was another person involved in the accident? Did anyone do anything to contribute to accident?
4. What other person other than the injured saw the accident?

CORRECTIVE ACTION TAKEN

1. What steps have been taken to prevent similar occurrences and what further recommendations are made? (Replace or repair equipment, instruct employee, or other action?
2. Follow up dates (For administration or safety committee).

Fig. 9.11. Accident report

SAFETY 9 (Rev. 8/74)

CIVIL SERVICE
USE ONLY

FORM 67 SENT______

SUPERVISORS REPORT OF ACCIDENT

THIS REPORT IS TO BE COMPLETED AND SENT TO THE SAFETY OFFICE WITHIN 72 HOURS AFTER THE TIME OF THE INJURY.

To Be Completed and Signed by the Injured's Supervisor

DEPARTMENT:______ SECTION:______ INDEX NO.______
NAME OF INJURED EMPLOYEE:______ SOCIAL SECURITY No:______
HOME ADDRESS OF EMPLOYEE:______ PHONE:______
DATE OF BIRTH:______ SEX: M __ F __; WAGE AT TIME OF ACCIDENT:______
NUMBER OF HOURS WORKED: PER DAY:______, PER WEEK:______, NUMBER OF DAYS PER WEEK:______
CLASSIFICATION:______ DATE OF HIRE:______
PLACE OF ACCIDENT:______ CITY/TOWN:______
DATE OF ACCIDENT:______ TIME:______ DATE REPORTED:______ TIME:______
DID EMPLOYEE RETURN TO WORK ON DATE OF INJURY?______ LOST TIME:______ DAYS/HRS.
WAS EMPLOYEE OFF WORK BEYOND DATE OF INJURY?______ IF SO, LAST DATE WORKED:______
NATURE OF INJURY (Specify Part of Body Injured):______
WAS EMPLOYEE ACTING IN REGULAR LINE OF DUTY WHEN INJURED?______
IF NO, EXPLAIN:______
HOW DID THE ACCIDENT OCCUR:______
WAS FIRST AID GIVEN:______ BY WHOM:______
DOCTOR:______ ADDRESS:______
HOSPITAL (IF ANY):______ ADDRESS:______
WHAT MACHINE, TOOL, SUBSTANCE, OR OBJECT WAS MOST CLOSELY CONNECTED WITH THE ACCIDENT:______
WERE MECHANICAL GUARDS OR OTHER SAFEGUARDS PROVIDED:______
WERE MECHANICAL GUARDS OR OTHER SAFEGUARDS USED:______
WHAT, IN YOUR OPINION, CAUSED THE ACCIDENT:______
DESCRIBE ANY UNSAFE ACT:______
DESCRIBE ANY UNSAFE CONDITION:______
WHAT HAS BEEN DONE TO PREVENT A SIMILAR ACCIDENT:______
WITNESSES:______

Complete and Return Original to
SAFETY OFFICE
DEPARTMENT OF PERSONNEL MANAGEMENT
Duplicate to Departmental File
Additional Copies as Desired

SIGNED:______
DATE:______
PHONE:______

Please Use Reverse Side For Further Particulars

Fig. 9.12. Accident report

e. Why and How of Holding Safety Meetings.

f. Safe Work Procedure No. 1, Preparations for Manhole Work.

g. DEEDS AND DATA (a monthly publication).

2. "Safety Manual", California Water Pollution Control Association, 18 North Mentor Avenue, Pasadena, California 91106.

3. "Entry into Confined Spaces", Hygiene Information Guide No. 26, Common Wealth of Pennyslvania, Department of Departmental Resources, Occupational Health, Harrisburg, Pennsylvania.

4. "Shoring Information", The Plank Company (West Coast Division), 29318 Pacific Street, Hayward, California 94544.

5. "Safety and Health in Excavation and Trenching Operations." A resource Supplement of OSHA 2092 consisting of 139 slides, 2 books (operations and reference readings). Available from General Services Administration, National Archives and Records Service, Audio Visual Center, Sales Branch, Washington, D.C. 20409. Price $21.00.

6. "Plant Safety and Good Housekeeping", by Robert Reed, Chapter 12 in Operation of Wastewater Treatment Plants, Kenneth D. Kerri, California State University, Sacramento, 6000 Jay Street, Sacramento, California 95819. Price for 17 chapter manual, $25.00.

7. "Safety Rules", published by the Metropolitan Water District of Southern California, 1111 Sunset Boulevard, Los Angeles, California 90012.

8. "Water Utilities Department Safety Guide", City of San Diego, San Digeo, California.

9. Contact other utility agencies (such as gas, electric and telephone) and find out what kind of safety programs they have that you can use. Their safety officers may be a good source for topic leaders on common problems or procedures.

END OF LESSON 3 OF 3 LESSONS
ON
SAFETY FOR THE
COLLECTION SYSTEM

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

(Lesson 3 of 3 Lessons)

Write the answers to these questions in your notebook before continuing with the Objective Test on page 9-79. The problem numbering continues from Lesson 2.

15. Why must utility agencies be contacted before excavating in an area?

16. Under what conditions do collection system workers receive serious electrical shock?

17. What are the sources of loud noises that could damage the hearing of a collection system worker?

18. How can collection system workers protect their hearing from loud noises?

19. How would you extinguish a fire?

20. Why should a collection system worker learn first aid?

21. Why are safety meetings important?

22. How would you develop a safety training program for your agency?

23. Why should an accident report be prepared after every accident?

24. What information should be included in an accident report?

SUGGESTED ANSWERS

CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

9.0A The First Law of Life is Safety and Survival.

9.0B The skill that most marks the professionalism of a collection system worker is the ability to carry out work assignments safely.

9.0C A reputation for a safe performance is an important professional characteristic. A safe performance will help you motivate, train and lead others which are supervisor characteristics that gain promotion.

9.0D The job of a collection system worker has many hazards for the careless worker. If you learn and practice safe procedures, your chances of injury can be minimized.

9.0E Safety statistics for collection system workers can be improved if everyone develops a desire to understand what causes accidents and how they can be prevented, coupled with a strong desire to work safely.

9.0F Safety has been defined as "a means of thinking far enough ahead to do the job at hand with proper tools at the proper time and in the proper manner."

9.1A The best indication that you might have contacted a disease from your work is that you don't feel well. If you have headaches, feel sick to your stomach, have diarrhoea, feel feverish or sleepy, you should see your physician.

9.1B The collection system worker must be constantly aware of the threat from pathogenic organisms. You can protect yourself by personal cleanliness, such as washing your hands, wearing gloves and proper clothing, and changing clothes before going home. Tetanus and polio immunizations are a must.

9.2A Gases found in sewers usually concentrate in low level or underground structures because many of the gases are heavier than air and are produced in the low levels in deposits and slimes.

9.2B The three basic classes of hazardous atmospheres are:

1. Poisonous or toxic
2. Explosive
3. Oxygen deficient

9.2C Some toxic gases that might find their way into a wastewater collection system include carbon monoxide, ammonia, chlorine, and hydrogen sulfide (H_2S).

9.2D Hydrogen sulfide is especially dangerous because:

1. It is generated from the anaerobic decomposition of organic matter in collection lines,
2. It is heavier than air, and
3. Our noses tend to lose their sensitivity to hydrogen sulfide and become unreliable detectors.

9.2E Possible ignition sources for an explosive atmosphere include a spark from an automobile, an improper tool, a shoe nail, a cigarette, or an open flame.

9.2F Your local fire department and gas company personnel can be helpful in identifying potential dischargers of hazardous combustible materials.

9.2G A shortage of oxygen to the worker produces a shortage of oxygen to the brain, which in turn makes the worker less alert to dangers that may result in death.

9.2H Try to measure the oxygen level in manholes before any ventilation occurs by removing the manhole cover so existing conditions can be measured and expected conditions for the workers can be measured too.

9.2I Before working in an oxygen deficient atmosphere, ventilate the space and wear an oxygen mask if necessary.

9.2J Hydrogen sulfide can be detected by the nose, but the nose becomes tired of smelling hydrogen sulfide and is not reliable. Hydrogen sulfide indicating badges or H_2S ampoules are the most reliable methods.

9.2K

Dangerous Gases	Method of Detection
Oxygen, O_2	Oxygen deficiency indicator
Gasoline Vapor	Combustible gas indicator
Carbon Monoxide, CO	CO ampoules
Hydrogen, H_2	Combustible gas indicator
Methane, CH_4	Combustible gas indicator
Hydrogen Sulfide, H_2S	H_2S ampoules
Carbon Dioxide, CO_2	Oxygen deficiency indicator
Nitrogen, N_2	Oxygen deficiency indicator
Ethane, C_2H_6	Combustible gas indicator
Chlorine, Cl_2	Odor

9.3A Defensive driving is careful driving to avoid accidents, while realizing all the special hazards that exist on the highway regardless of who has the legal right of way.

9.3B When working in traffic, you should always park the truck with brakes set and roof light flashing in such a position that careless traffic must "plow" into the truck before it can "run over" the crew working in or around a manhole.

9.3C People can be warned of a truck backing up by having a passenger get out and direct the driver and by having the truck equipped with bells, horns or other types of alarms that sound off when the truck backs up.

9.3D Safety cones are placed around a vehicle to alert traffic of the location of the vehicle. When picking up traffic cones, look for tools not put away and hazards (children, toys) that might be run over when leaving the job site.

9.3E Traffic can be directed around a work site by use of safety cones, barricades, signs and flagmen.

9.3F Additional training and guidance regarding the proper methods to route traffic around a job site can be obtained by consulting the police or highway patrol.

9.4A Shoring is used to prevent cave-ins from excavations that could bury and kill workers.

9.4B Excavation or trench sidewall cave-ins can be caused by:

1. Failure to shore, possibly because of a deliberate short cut to save time or expense.
2. Inadequate shoring because of lack of knowledge or misjudgement of soil stability.
3. Failure of shoring because of unsuspected bank loading caused by traffic or machinery vibration.
4. Inadequate shoring maintenance or replacement after changes occur in the soils surrounding an excavation as a result of construction work or heavy rains.
5. Failure of shoring material.
6. Placement of spoil too near the trench edge.
7. Trench wall undercutting.

9.4C OSHA stands for Occupational Safety and Health Act of 1970. OSHA standards describe measures that must be taken to provide workers with a safe environment and to protect them from accidents.

9.4D Yes. Special shoring requirements are necessary when vehicles or other equipment must operate near a recently excavated trench to prevent cave-ins.

9.4E Care must be taken when operating equipment near shoring to protect the bracing and shoring from damage by the equipment.

9.5A Hazards that may be encountered when working in and around manholes include:

1. Traffic. Both vehicular and pedestrian.
2. Adverse atmospheres. Flammable and poisonous gases or a deficiency of oxygen.
3. Physical and structural conditions. Loose or corroded rungs or dangerous liquids.

9.5B Tests for combustible or toxic gases are to be conducted in the following order:

1. Explosimeter. Test for explosive conditions.
2. Combustible gas-oxygen deficiency. Also test for oxygen deficiency.
3. Hydrogen sulfide instrument or detector badge. Test for toxic gases.

9.5C If the atmosphere in a confined space is still hazardous from a toxic gas or an oxygen deficiency after ventilation, contact your work station or supervisor immediately. If you must enter the confined space, wear a self-contained breathing unit or apparatus and be sure someone is standing by with another self-contained breathing unit or apparatus for rescue operations if necessary.

9.5D True. Never enter a confined space deemed hazardous because of combustible gas mixtures.

9.5E A portable blower should operate a minimum of 20 minutes in a work area prior to permitting a worker to enter a confined space.

9.5F At the first sign of nausea or loss of alertness, the worker should immediately get into the open air. The topside worker should be especially alert for problems because the worker in the confined space may not notice them.

9.6A Safety hazards around construction sites include:

1. Children,
2. Traffic,
3. Construction equipment,
4. Drilling and blasting of rock,
5. Trench and excavation cave-ins,
6. Underground utilities,
7. Overhead electrical lines.

9.6B An inspector must watch out for similar safety hazards when inspecting either old or new wastewater collection systems. Construction equipment and conditions may be an additional hazard for new systems. Gases found in sewers may be a more likely hazard around old wastewater collection systems.

9.6C When cleaning sewers, be careful:

1. Not to flood basements or homes,
2. To route traffic safely around job site,
3. To test for gases found in sewers, provide adequate ventilation and wear safety equipment before entering a manhole or confined space.

9.7A Three additional job hazards to collection system workers include:

1. Radiological,
2. Electrical,
3. Noise.

9.7B Radioactive isotopes that enter wastewater collection systems come from hospitals, research labs and various industries.

9.7C Electrical shock can occur especially where the hazard of a ground and moisture are present.

9.7D Safety locks must be placed on all electrical circuits or equipment out of service for repair. Tags must indicate date of lock out and signature of person responsible for lock out.

9.7E Loud noises (over 85 decibels) from gas engines, air hammers and other equipment can cause permanent ear damage.

9.8A The different types of materials that can cause fires are ordinary combustibles, flammable liquids, electricity and metals.

9.8B The different types or classes of fires can be extinguished by the following methods:

Class	Method of Extinguishing
A	Water
B	Foam, carbon dioxide, dry chemicals
C	Carbon dioxide, dry chemicals
D	Carbon dioxide

9.8C Fire fighting equipment and extinguishers should be inspected on a regular basis such as every 3 or 6 months and after each use.

9.8D For a badly cut hand, immediately cover wound with cleanest available cloth and try to stop bleeding. Call for medical help.

9.8E For a broken arm, try to support arm so it won't move and get to a doctor.

9.9A Several types of meetings may be used in safety training programs. They can range from highly organized meetings to tail gate safety sessions to informal get togethers or bull sessions.

9.9B Effective safety meetings result when:

1. Everyone understands the basic safety concepts,
2. Everyone participates and accepts their personal responsibility,
3. Adequate safety equipment is available for demonstration and use,
4. Everyone realizes that safety is a continuing learning and re-learning process,
5. Accidents are studied and reviewed,
6. Every appropriate detail of work is a subject for a safety discussion.

9.9C Tail gate safety sessions consist of a small group of workers gathered around the tail gate of a pickup or truck to discuss safety.

9.9D Topics covered in safety meetings should be simple and refer to subjects that the crew is involved in every day or a new or special job that the crew has been assigned.

9.9E Whatever you reply is the correct answer because it is your opinion.

OBJECTIVE TEST

CHAPTER 9. SAFETY FOR THE COLLECTION SYSTEM WORKER

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

1. What one skill most marks the professionalism of a collection system worker? The ability to do the following:
   1. Get the job done quickly.
   2. Get the job done cheaply.
   3. Get along with the rest of the crew.
   4. Meet the public.
   5. Carry out work assignments safely.
2. What is the main reason for the poor accident record of collection system workers in the past?
   1. Lack of interest.
   2. Lack of initiative.
   3. Lack of training.
   4. Negligence.
   5. Ignorance.
3. We can improve the poor safety record of the past by
   1. Understanding what causes accidents.
   2. Determining how accidents can be prevented.
   3. Trying to work safely.
   4. Attending and participating in safety meetings.
   5. Learning how to do your job safely and then doing your job safely.
4. Hazards encountered by collection system workers include:
   1. Infections.
   2. Infectious diseases.
   3. Explosive gases.
   4. Traffic.
   5. Cave-ins.

GO TO NEXT PAGE

5. Toxic gases include:

   1. Hydrogen sulfide.
   2. Ammonia.
   3. Chlorine.
   4. Carbon dioxide.
   5. Oxygen.

6. Wastewater collection system workers can use an oxygen deficiency indicator to test for presence of

   1. Oxygen.
   2. Hydrogen.
   3. Nitrogen.
   4. Carbon dioxide.
   5. Hydrogen sulfide.

7. Collection system workers must learn to drive various types of vehicles safely because

   1. Driving is one of the nation's main killers.
   2. Trucks often are more difficult to drive than cars.
   3. A tank truck full of water is difficult to handle.
   4. Work often takes place in traffic.
   5. Workers want to avoid accidents.

8. Cave-ins can be caused by

   1. Earthquakes.
   2. Stable soil.
   3. Improper shoring.
   4. Changing conditions.
   5. Placing spoil away from edge of trench.

9. When evaluating shoring conditions consider

   1. Pipe material.
   2. Fluctuations in weather conditions.
   3. Types of joints.
   4. Sources of vibrations near trench.
   5. Structures near trench.

GO TO NEXT PAGE

10. Hazards connected with manhole work include:

    1. Traffic.
    2. Insects.
    3. Toxic gases.
    4. Failure of pipes.
    5. Oxygen deficiency.

11. You should get out of a manhole as soon as you start feeling

    1. Thirsty.
    2. Like sneezing.
    3. Sick to your stomach.
    4. Sleepy.
    5. Dirty.

12. When an inspector discovers an unsafe condition, the inspector should

    1. Fix it immediately.
    2. Stop work until the condition is corrected.
    3. Leave the area before someone is injured.
    4. Record the condition in project diary.
    5. Notify workers in the area.

13. Harmful radioactive isotopes can get into wastewater collection systems from

    1. Hospitals.
    2. Inflow/infiltration.
    3. Homes.
    4. Tracer studies.
    5. Research labs.

14. Electrical fires can be extinguished by using

    1. Reverse current.
    2. Compressed air.
    3. Carbon dioxide.
    4. Water.
    5. Metals.

GO TO NEXT PAGE

15. If a person is injured, first

    1. Restore breathing.
    2. Stop bleeding.
    3. Fix broken bones.
    4. Make victim comfortable.
    5. Call a physician.

16. Safety programs are effective when

    1. Basic safety concepts and practices are thoroughly understood by all.
    2. Everyone participates and accepts their personal responsibilities for safety.
    3. Adequate safety equipment is available.
    4. Everyone realizes that safety is a continuing learning and re-learning process.
    5. Everyone realizes they should stop anyone performing an unsafe act and explain safe procedures.

17. Information required on an accident report include:

    1. Description of accident.
    2. Corrective action taken.
    3. What injured person did to cause accident.
    4. How many people were involved in accident.
    5. If defective equipment or unsafe conditions contributed to the accident.

GO TO NEXT PAGE

Review Questions

18. What items should be considered when reviewing plans and specifications for a new lift station?

    1. Provisions for cleaning wet well.
    2. Facilities for ventilating lift station.
    3. Telemetry system.
    4. Reputation of the contractor.
    5. Landscaping around lift station.

19. Frequency of lift station visits depend on

    1. Evaluation of past records.
    2. How often standard charts and tables say stations should be visited.
    3. Reliability of telemetry system.
    4. Damages that could result from a failure.
    5. Design of facility and equipment installed in lift station.

20. Items that require maintenance in a lift station include:

    1. Hydrogen sulfide.
    2. Pumps.
    3. Records.
    4. Controls.
    5. Ventilation equipment.

CHAPTER 10

ADMINISTRATION

by

Neal R. Townley

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OBJECTIVES

CHAPTER 10. ADMINISTRATION

After completion of Chapter 10 you should be able to do the following:

1. Read an area map, a master map, a section map and an assessor's map.
2. Explain the importance of and need for maps.
3. Keep maps up to date.
4. Prepare and maintain records essential for budgeting, scheduling and meeting legal requirements.
5. Schedule emergency, routine, preventive and corrective maintenance.
6. Develop and justify staffing and equipment requirements for your program.
7. Hire new workers.
8. Organize an effective public relations program for your agency.
9. Write an informative report.

CHAPTER 10. ADMINISTRATION

(Lesson 1 of 5 Lessons)

10.0 INTRODUCTION

The material covered in this chapter deals exclusively with wastewater collection systems. The specific aspects of "Administration" included in this chapter are:

- Mapping
- Records
- Scheduling of Maintenance Work
- Staffing Requirements
- Tool and Equipment Requirements
- Public Relations
- Report Writing
- People

Read the list again. Think about it. We believe the most important aspects of effective administration are included in this list. Any supervisor, regardless of the size of the collection system, must be concerned with these elements of administration.

These topics will be presented, in sequence, as they are listed above. This is not to suggest this particular sequence is relative to the degree of importance that should be placed on these aspects of administration. In actual practice there are many circumstances that will influence the importance that is placed on these areas of administration by individual supervisors or managers.

When all of these topics are tied together, you begin to get a picture of the job of an administrator or manager. This is a very responsible position. Maps and records must be accurate and kept up to date. Priorities must be established so work can be scheduled and staffing and equipment requirements determined. Authority must be delegated and a chain of command established. On the basis of need and funds available, budgets must be prepared, funds allocated, and accounts kept of financial expenditures. Probably the most important jobs of any administrator or manager include coordinating the activities of the crews, keeping other agencies informed of your activities, learning of their activities and solving problems. Chapter 11, Organization for System Operation and Maintenance, discusses how to organize and coordinate the aspects discussed in this chapter into an efficient collection system agency.

10.1 MAPPING

In the introduction we stated a specific sequence that would be followed. The basis for selecting that sequence was time. At what time will maps become necessary? Immediately. Given the responsibility for operating and maintaining a wastewater collection system, the first things you will need to know are Where is it? and How large is it? You will need a map of your system.

The need for mapping is basic to any collection system. An accurate location of the components and an indication of the size of the collection system will be required before any maintenance activities or progress can be planned or implemented. As a collection system grows, staffing will increase, maintenance activities will expand, and a corresponding need for better, more detailed maps will become evident.

Maps must indicate what has been constructed, where, what size, materials used, and conditions encountered. A detailed record or documentation of what is underground is critical for the successful operation and maintenance of a wastewater collection system.

10.10 Importance of and Need for Mapping

Under certain conditions it might be possible for one worker to operate a small collection system without the benefit of any formal map system. In time, the worker could become familiar enough with the collection system to operate out of a hat, or from memory. This practice is not recommended, regardless of how small the collection system. Inevitably, at some time, this worker, the hat, and the worker's memory will be unavailable. When that time comes the worker's replacement or successor will have many problems.

Collection systems of a significant size present an entirely different situation. The number of workers involved will make it impossible for each of them to become thoroughly familiar with the entire collection system. Daily assignments will send workers to parts of the system they may never have seen or even knew existed. Maps will be needed for this simple, daily function of directing workers to their assigned work areas.

QUESTIONS

10.1A List the most important aspects of effective administration or supervision for persons working with wastewater collection systems.

10.1B Why are maps of a wastewater collection system important?

10.11 Information Required on Maps

A. Locations.

1. Sewers. In streets, location should be shown in relation to the center line of the street. In easements, indicate location in relation to property lines. Often sewers are located by distance and direction from surveyors' reference points such as street center lines, curb lines and bench marks.

2. Building sewer connections. Distance (in feet) should be indicated, measured from downstream manhole. If available, show location of service line at property line (measured from a property corner).

3. Manholes. Care should be exercised to indicate manhole locations accurately, by footage from connecting manholes and by scale in relation to property lines and property corners. This is especially important because considerable time can be lost in seeking manholes that have been paved over in streets or covered by landscaping, regrading or vegetation growth in rear easements.

4. Flusher branches. Collection systems will contain many fewer flusher branches than manholes. However, when needed to provide access to a plugged sewer, they become equally essential. Being smaller in size and metal mass, they are more difficult to find by sight or by electronic locators. For these reasons equal care should be given to designating their location on maps.

5. Other utilities. The location of other underground utilities must be known before any new construction or repair work is started. Whether or not this information is readily available to you will depend on the size of your community, the engineering staff, and the total utility system that is underground. Most utility companies will and should mark the locations of their system on the pavement for you. Locations of other underground utilities are helpful when planning either new construction or repair work. Many utility agencies are associated with an organization that will notify other utility agencies whenever underground work is scheduled. See Chapter 6, Section 6.162, Meet with Utility Companies.

6. Boundaries. Jurisdictional boundaries of surrounding agencies also should be shown.

B. Identification. Aside from location, identification by number is the next most important benefit to be realized from good maps. Accurate identification will provide the basis for an accurate record system. Items to be identified by specific numbers include:

1. Manholes. All manholes should be identified by a specific number and these numbers should never change. Extension of a collection system will result in the addition of manholes. Such additions must be shown on maps immediately, in order to keep the maps current. Management must provide a means of insuring that maps are kept current and also checking to be sure the map updating is done. Occasionally, draftsmen may succumb to the temptation of

reassigning new numbers to existing manholes in the interest of keeping a particular portion of the map neat and sequential. Such practice will make existing records, based on original numbers, useless. Additional manholes, when added on the mapping system or page of a mapping system, must be assigned new numbers. For example, if a new manhole is constructed between manholes #1 and #2, the new manhole could be simply identified as manhole #1-A. To avoid having manholes with high numbers, start numbering the manholes on each page with the number 1. Different agencies have different procedures for numbering manholes and any procedure is satisfactory as long as it is simple and not confusing.

2. Flusher branches. As with manholes, flusher branches should be identified by their own specific numbers.

3. Sewers. Each section of sewer between manholes should be identified or designated as an individual section. This individual section can be identified simply by indicating the numbers of the two manholes which the section connects.

4. Properties served. Individual parcels of property, which are connected or have the potential of being connected to the collection system, should be identified. Address and lot number or assessor's parcel number are commonly used to provide this information.

5. Cleanouts at property line. Specific identification, by individual number and location, is a matter of choice depending on the scope of a particular record keeping system. Cleanouts are commonly identified by reference to the particular parcel of property they serve.

C. Elevations. Known elevations are vital to gravity sewer systems. They are of great importance to collection system workers. Essential elevations that should be shown on maps are:

1. Flow lines. Flow lines, also called inverts, should be indicated on maps at the site of each manhole for all sewers entering and leaving the manhole.

2. Manhole rim elevations. If rim elevations are not shown, then depth of manholes should be indicated. Rim elevation can be computed by adding manhole depth to flow line elevation.

3. Depth of sewer. If not specifically indicated, this can be determined by given flow line elevations for upstream and downstream manholes. This calculation also will indicate fall or grade of sewer between manholes.

4. Depth of house service line at property line. Often this elevation is not provided on maps or construction plans. Many local construction codes merely stipulate a minimum and maximum acceptable depth, except in cases of unusual topographical conditions. If possible, or practical, a good practice would be to accumulate and record all such elevations acquired during the normal course of inspection, maintenance or repair activities. This information would then be available to be included in future updating of maps.

D. Footage. Include the following:

1. Distance between manholes. This distance should be indicated, in feet, measured from center to center of manholes.

2. Widths of streets, right of ways and easements.

3. Front, rear and lateral lot lines of all properties being served or with the potential of being served.

E. Type of pipe. Such as:

1. Vitrified clay (VCP)
2. Cast iron (CIP)
3. Reinforced concrete (RCP)
4. Concrete (CP)
5. Asbestos cement (ACP)
6. Others. There are other types of pipe, less commonly used, which should be identified either by brand names or designations familiar to a particular geographical area.

F. Flow direction. Flow direction should be indicated by a directional arrow.

G. Force mains. Force mains should be specifically indicated and identified. Depth, type of pipe, size and footage also should be given.

H. Soil conditions. This information is not often shown on maps. Unusual soil conditions would be of great importance and a significant safety factor to future repair crews who would be reexcavating in disturbed ground. Such information could be acquired at time of construction and noted on "as built plans" by inspectors. Soil conditions should then be included in any future updating of maps.

I. Properties connected to collection system. This information may not be available when maps are originally compiled. Properties connected should be added at time of connection. An ideal method is to record connection permit numbers, as soon as they are issued, on tracings of map system.

J. Inventory. Totals should include the number of manholes, flusher branches, house connections and footages for each size pipe. This may not be practical on large maps covering large areas because of the huge totals required and the small scale of such maps. Inventory totals can and should be done when maps have been divided into sections or pages. On such maps of adequate scale, totals for each page or section can be easily determined. Totals for each page or section can be easily added to provide the total for each book or map (which are divided into sections). By adding these book totals or map totals, the total for the entire collection system can be determined.

K. Scale and North Arrow. Scale of map must be shown so distances measured on map can be converted to actual distances in the field. A north arrow is important so the map can be oriented or pointed in the proper direction.

L. Date. All maps and/or map pages should indicate the date of latest revision.

QUESTIONS

10.1C List as many items of information as you can recall that should be available on wastewater collection system maps.

10.1D How should manholes be identified on maps?

10.1E What elevations should be shown on maps?

10.1F Why should soil conditions be shown on maps?

10.12 Type and Size of Maps

For the collection system worker in the field, an ideal map would be one drawn for your specific use and needs. This map would provide all the details you might need, on a scale large enough to be easily read. The size should be convenient and easily handled in the field in all kinds of weather. Unfortunately, few, if any, maps can meet these requirements.

Developing a mapping system for the sole purpose of field use is rarely done due to the costs involved. However, by using various types of available maps and adapting them to fit most of our needs, it is possible to provide collection system workers with mapping systems that are functional. Common types in use are:

A. Area maps. Most agencies, regardless of size, will compile a map showing how the entire area is served by its wastewater collection system. Such maps will usually outline only major items of concern. These might include major trunk lines, pumping stations, treatment plants and major thoroughfares, and their relation to communities, districts, receiving waters and/or streams.

B. Master maps. The size of the area being served will be a determining factor as to how many maps will be needed. A small system may require only one map. Large areas obviously will need more maps. A master map may be needed for each community or district within the whole area. Master maps should be drawn on a scale capable of indicating, at least, the approximate location of the collection system, including manholes, in relation to all streets and properties within the area.

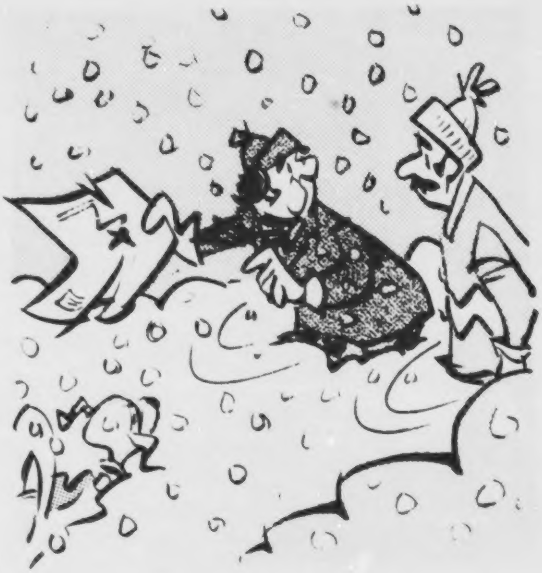
C. Section maps. These become available whenever master maps are divided into sections. They should be drawn to a scale that will allow more detail and of a size practical for use in the field. The scale should provide ample space to allow identification numbers, footages and pipe sizes to be clearly shown.

D. Assessor's maps. In most municipalities assessor or real estate departments have an accurate and up-to-date mapping system. It is their responsibility to keep accurate, legal records on each individual parcel of property. Their maps have been divided into pages and the pages bound into books.

They provide a scale adequate for detailed information. Recorded right of ways, street names and widths, property identifications and sizes are included. These map books, being of a size suitable for field use, are ideal for a maintenance department to adopt and adapt for use as collection system maps. Usually you can obtain tracings of these maps from the originating department and overlay your collection system on these tracings.

E. Grid Coordinate Maps. All states have developed a state coordinate system. Surveyors developed the state coordinate system for the purpose of connecting all their surveys, such as land surveys and highway surveys, to the same reference stations. Should monuments which mark land corners or other reference points ever be destroyed, they may be readily and accurately reestablished on the basis of their coordinates and a new survey originating at other stations in the network.

If all utility agencies (water, wastewater, gas, telephone, electricity) identified the location of all the important points of their underground facilities on the same coordinate system, our jobs requiring excavation would be much easier with respect to the location of other utilities. Even after floods or hurricanes, or during periods of heavy snow, a grid coordinate system would help locate underground utilities and expedite the return of utility systems to service. Whether your agency is part of your state coordinate system or a local system, the



procedures for identifying and locating facilities are similar. A goal for every wastewater collection agency could be to have their engineer or surveyor develop and implement a plan for all utility agencies to have their underground systems located by the same grid coordinate system.

The state coordinate system or a local coordinate system is represented by two sets of parallel straight lines, intersecting at right angles (Figure 10.1). The resulting network is called a grid.

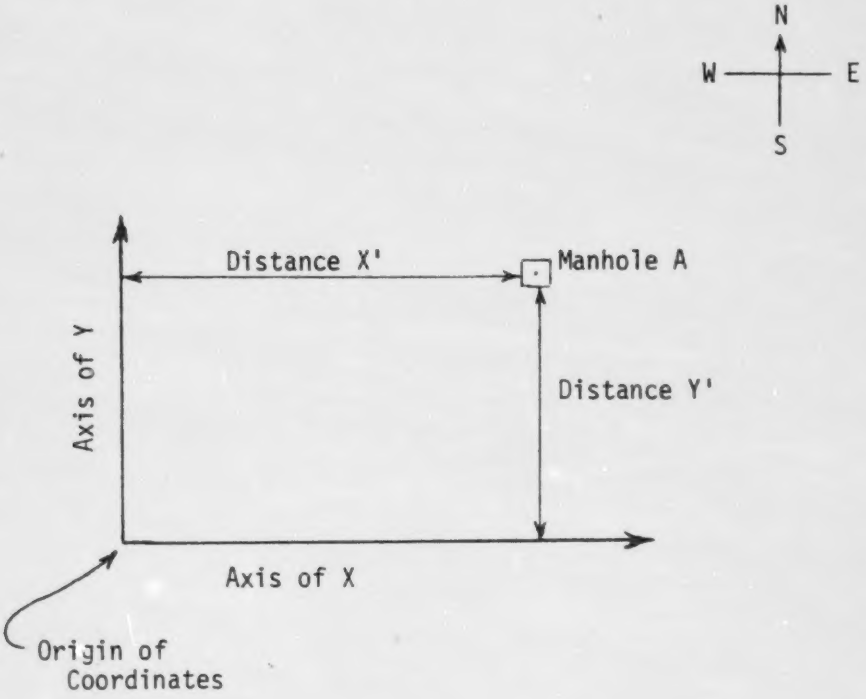

N
W
E
S
Distance X'
Manhole A
Axis of Y
Distance Y'
Axis of X
Origin of Coordinates

Fig. 10.1. Grid coordinate system

Grids are bordered on the south by the Axis of X and on the west by the Axis of Y. Distances along both axes are measured in feet. The point of intersection of these axes is called the origin of coordinates.

The position of a manhole or other facility represented on the grid can be identified by stating the two distances termed coordinates. One of these distances, known as the x-coordinate, gives the position in an east-and-west direction (Distance X' on Figure 10.1). The other distance, known as the y-coordinate, gives the position in a north-and-south direction (Distance Y' on Figure 10.1).

Since surveyors have already established state grid systems in every state, your wastewater collection system can be identified with the state system by surveyors or civil engineers. Other utility agencies such as water, gas, electricity, telephone, drainage, roads and streets, may or may not be connected to your state grid coordinate system; but they too can be connected.

When maps are drawn or aerial photographs taken and the state grid coordinate system and the location of wastewater collection facilities are shown, you can use any convenient scale. Be sure to select a scale similar to other maps you use and a scale that is neither too large or too small. Manhole A in Figure 10.2 may have the following designation on your state grid coordinate map:

x = 828,376.24

y = 106,249.01 .

These numbers represent distances measured in feet (to the nearest hundredth) north and south (axis of Y) and east and west (axis of X) from a fixed point.

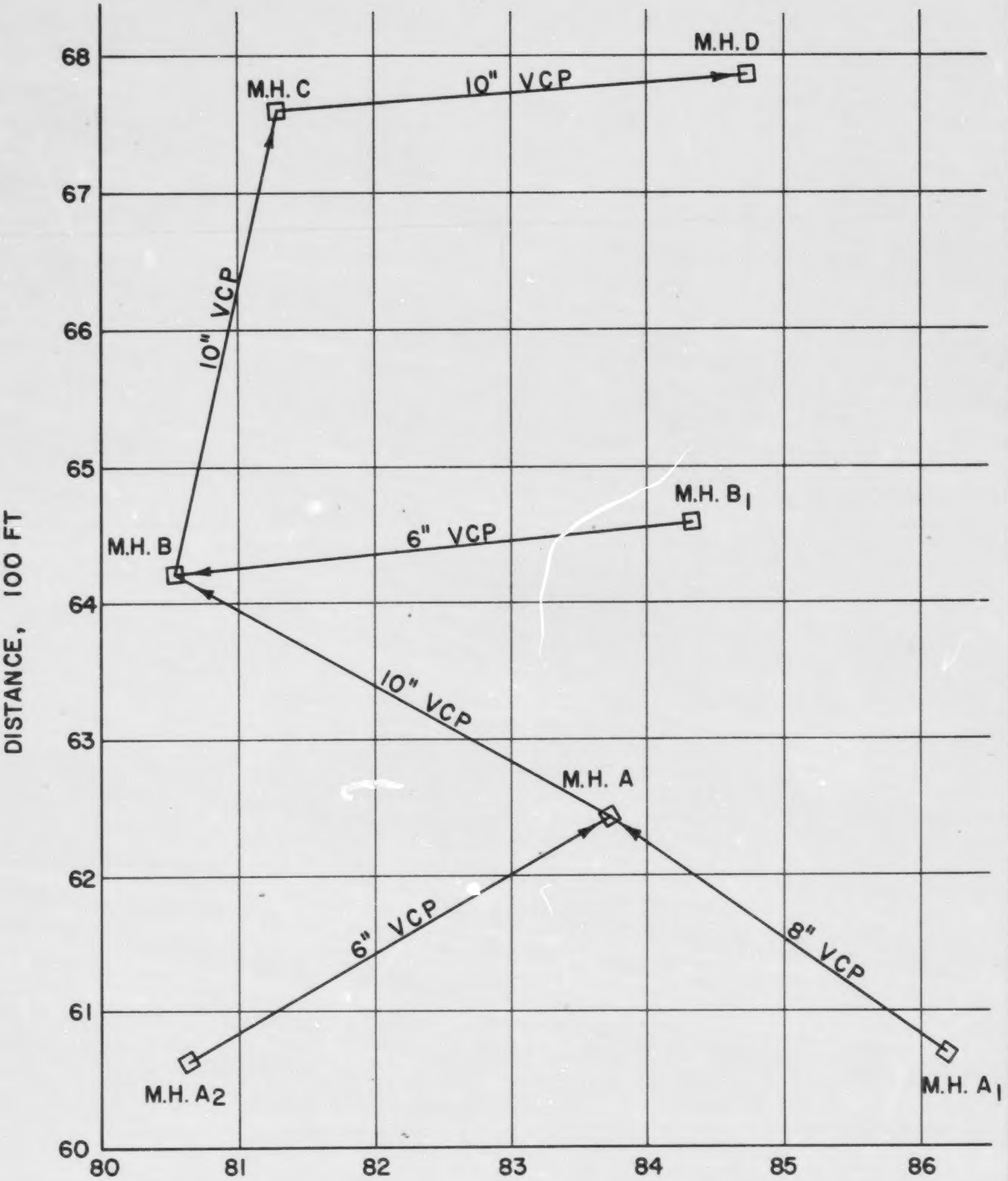

M.H. D
10" VCP
M.H. C
10" VCP
M.H. B1
6" VCP
M.H. B
10" VCP
M.H. A
6" VCP
8" VCP
M.H. A2
M.H. A1
68
67
66
65
64
63
62
61
60
80
81
82
83
84
85
86
DISTANCE, 100 FT
DISTANCE, 100 FT

Fig. 10.2. Utility agency grid coordinate map

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For the sake of simplicity you may wish to drop the first number or even the first two numbers if you have a small system. In this case, manhole A would be identified as:

x = 28,376.24

y = 06,249.01

or simply x, y = 28,376.24, 06,249.01.

To help illustrate what a grid coordinate map looks like and how to use it, let's look up some examples on Figure 10.2. The location of:

1. Manhole A is 8,376.24 , 6,249.04
2. Manhole B is 8,061.02 , 6,423.72
3. Manhole C is 8,135.66 , 6,766.81.

With a grid coordinate map, the coordinates of a manhole can be given and the manhole can be located rather easily. For example, given the coordinates listed below, what is name or designation of the manhole?

4. Manhole 8,470.22, 6,786.17 is Manhole D
5. Manhole 8,070.81, 6,068.07 is Manhole A2
6. Manhole 8,615.67, 6,072.23 is Manhole A1

Since manhole covers can be rotated and streets paved, the exact coordinates of a grid system can be difficult to locate accurately. For this reason reference points are used as starting points or points that can be used to relocate other points. Reference points are permanent markers such as a concrete monument with a cross or nail in the top or possibly a cross marked on a curb. From the permanent locations with known grid coordinates, surveyors can locate other utilities or tie other utilities to a grid coordinate system.

If every utility agency would use the state grid coordinate system, key points on any agency's underground facilities can be located on your maps and potential problem areas identified. With everyone using United States Geological Survey (USGS) bench marks for elevations, the elevations of underground facilities can be compared too.

If you would like to learn more about state coordinate systems or if your agency's engineers wish more information, the following U.S. Department of Commerce, Coast and Geodetic Survey, references are very good. They are no longer available from the Superintendent of Documents, Washington, D.C., but your local library may be able to borrow a copy from your State Library.

1. "Manual of Traverse Computation on the Lambert Grid" by Oscar S. Adams and Charles N. Claire, Special Publication No. 194.

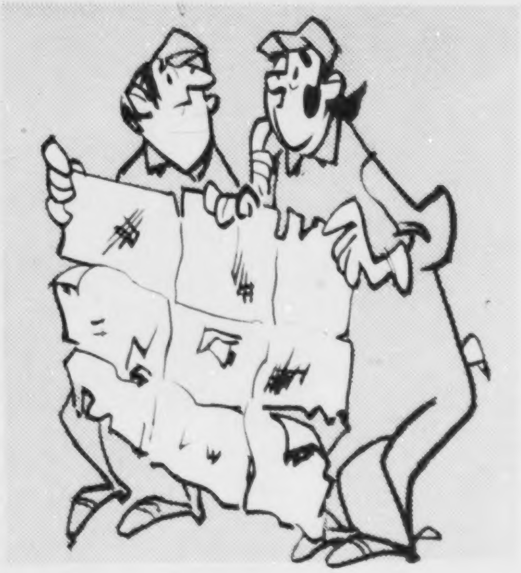
2. "Manual of Traverse Computation on the Transverse Mercator Grid" by Oscar S. Adams and Charles N. Claire, Special Publication No. 195.

3. "The State Coordinate Systems (A Manual for Surveyors)" by Hugh C. Mitchell and Lansing G. Simmons, Special Publication No. 235.

10.13 Examples of Mapping

Because of their scope and the many details needed in any mapping system, it is difficult by mere descriptive words to illustrate effectively their make up. Included are three samples that should provide a clearer picture of information required on maps.

A. Master map. Figure 10.3 illustrates a small section of a master map that was drawn to a 1" = 800' scale. The total size of the entire map measures 4' x 4' and covers one sanitation district serving a population of 55,000 people. No other map



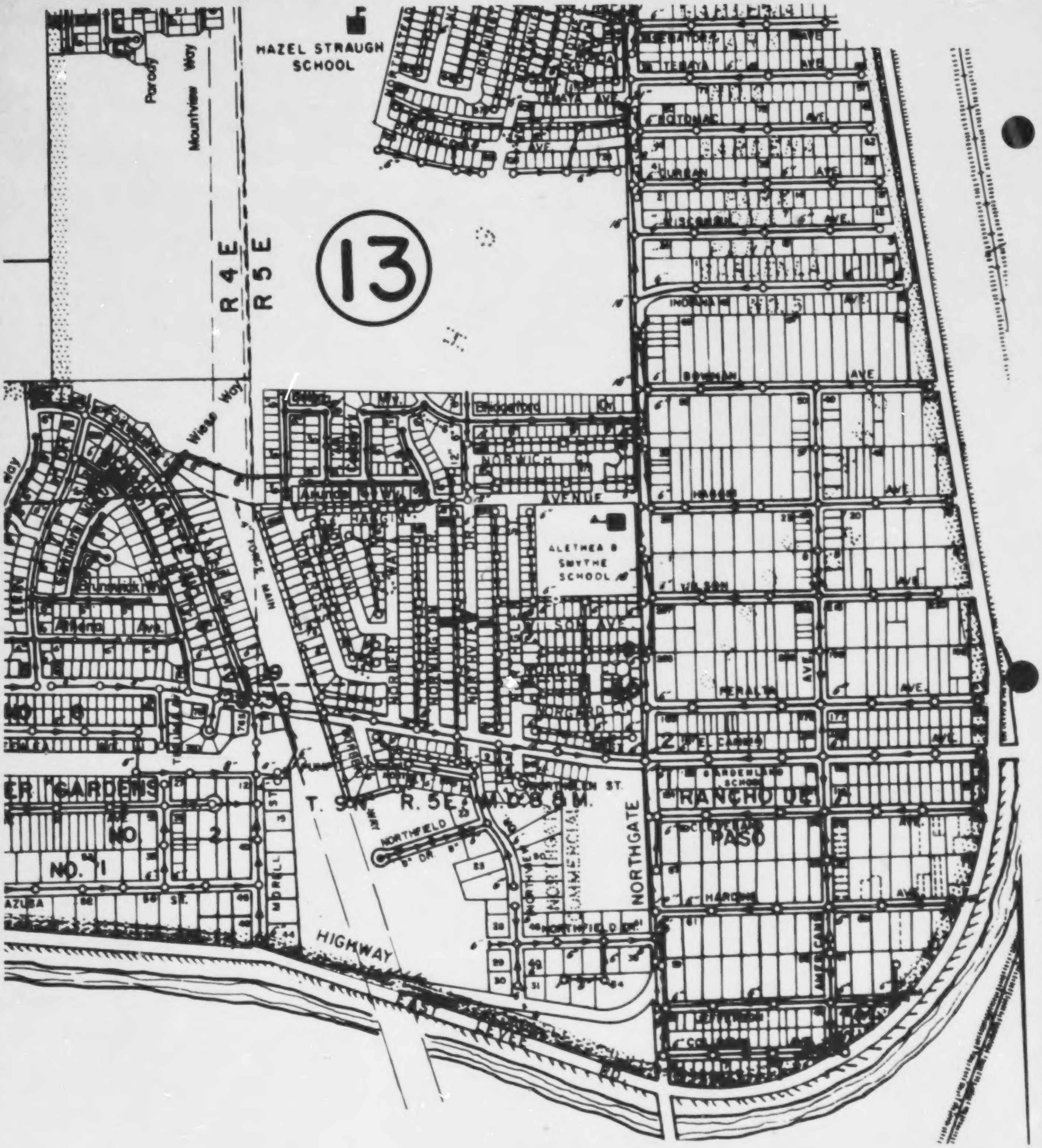

HAZEL STRAUGH SCHOOL
Parody
Mountview Way
R 4 E
R 5 E
13
Wiese Way
ALETHEA B SMYTHE SCHOOL
NORTHGATE
HIGHWAY
EAST LEVEE
T. 9N. R. 5E. M.D.B.&M.
RANCHO DEL PASO
GARDENS
NO. 1
NO. 2
NORTHFIELD
TERAYA AVE.
POTOMAC AVE.
DURBAN AVE.
WISCONSIN AVE.
INDIANA
BOWMAN AVE.
HARRIS AVE.
NORWICH AVENUE
PERALTA AVE.
NORTHFIELD DR.
AMERICAN
MORELL ST.
AZUSA ST.
Athens Ave.
Brunswick Wy.

Fig. 10.3. Master Map

Scale: 1" = 800'
before reduction

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being available, it could be used by collection system workers in the field. This map would, however, have some disadvantages. Its size makes it difficult to use. In the field it would be worn out by continued rolling and unrolling or repeated folding and unfolding. Frequent replacement would probably be necessary. The scale makes it difficult to read and provides too little space for necessary details and identifications.

B. Section map. Figure 10.4 illustrates a portion of one sheet of a master map (Figure 10.3) that was divided into 24 sheets. Each sheet measures 2' x 3'. Drawn on a scale of 1" = 400', it has ample room for more detail and is easier to read. Used a sheet at a time, it could be suitable for field use. It would, however, be subject to the same abuses in handling as the map shown in Figure 10.3.

C. Assessor's maps. Figure 10.5 is the most detailed of the three example maps. Drawn to a scale of 1" = 100', it includes almost all the desirable items of detail outlined in Section 10.11, Information Required on Maps. Consult the legends shown in Figure 10.6 and Figure 10.7. They will enable you to interpret the information included on the Assessor's map. The actual size, 12" x 18", when bound into books, makes it ideal for field use. Protected by hard covers, it is very durable and will last for years during everyday use in the field. Replacement of pages due to damage or updating can be done on a page by page basis. The example shown is one page of one book. The complete set totals 128 books, covers a countywide collection system of 1,500 miles of sewers, and serves a population of 400,000. This entire set of map books can be easily carried and safely stored in one compartment of a utility type truck commonly used by maintenance departments. Although assessor's maps contain more information than you need to do your job, very often they are the only maps available with the necessary details.

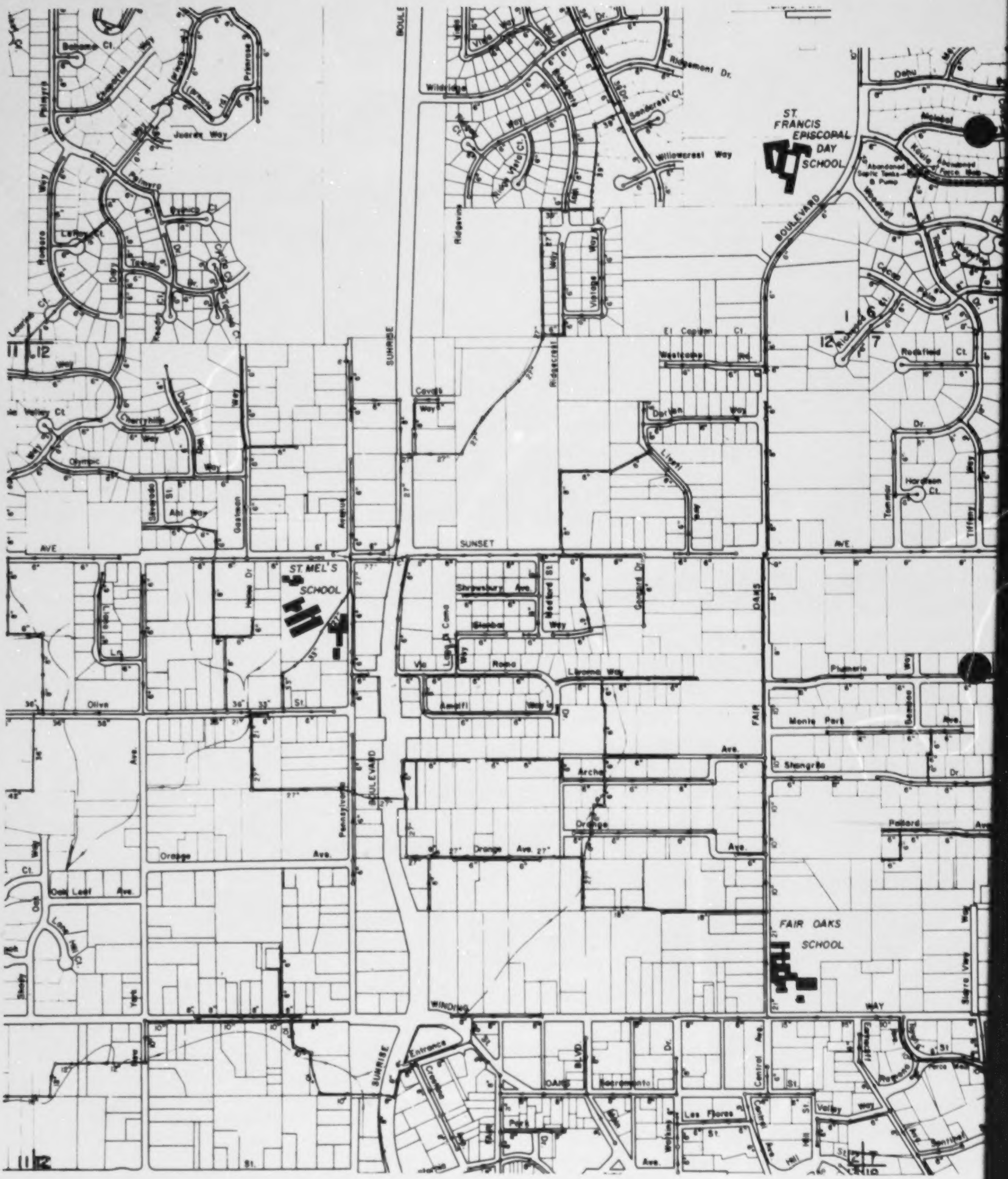
ST. FRANCIS EPISCOPAL DAY SCHOOL
ST. MEL'S SCHOOL
FAIR OAKS SCHOOL
SUNRISE BOULEVARD
BOULEVARD
SUNSET AVE.
FAIR OAKS
WINDING WAY
Olive St.
Orange Ave.
Pennsylvania Avenue
Palmyra
Juarez Way
Ridgemont Dr.
Sandcrest Ct.
Willowcrest Way
Ridgecrest
Vintage Way
El Capitan Ct.
Westcome Rd.
Dorian Way
Cherryhills
Olympic
Gustman
Shrewsbury Ave.
Livorno Way
Amalfi
Archer
Orange
Oak Leaf Ave.
Plumeria
Monte Park Ave.
Shangri-la Dr.
Abandoned Septic Tanks & Pump
Abandoned Force Main
Rockfield Ct.
Hardison Ct.
Entrance
Sacramento
Los Flores
Central Ave.
Valley Way
1
6
12
7
11
12

Fig. 10.4. Section Map

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Scale: 1" = 400'
before reduction

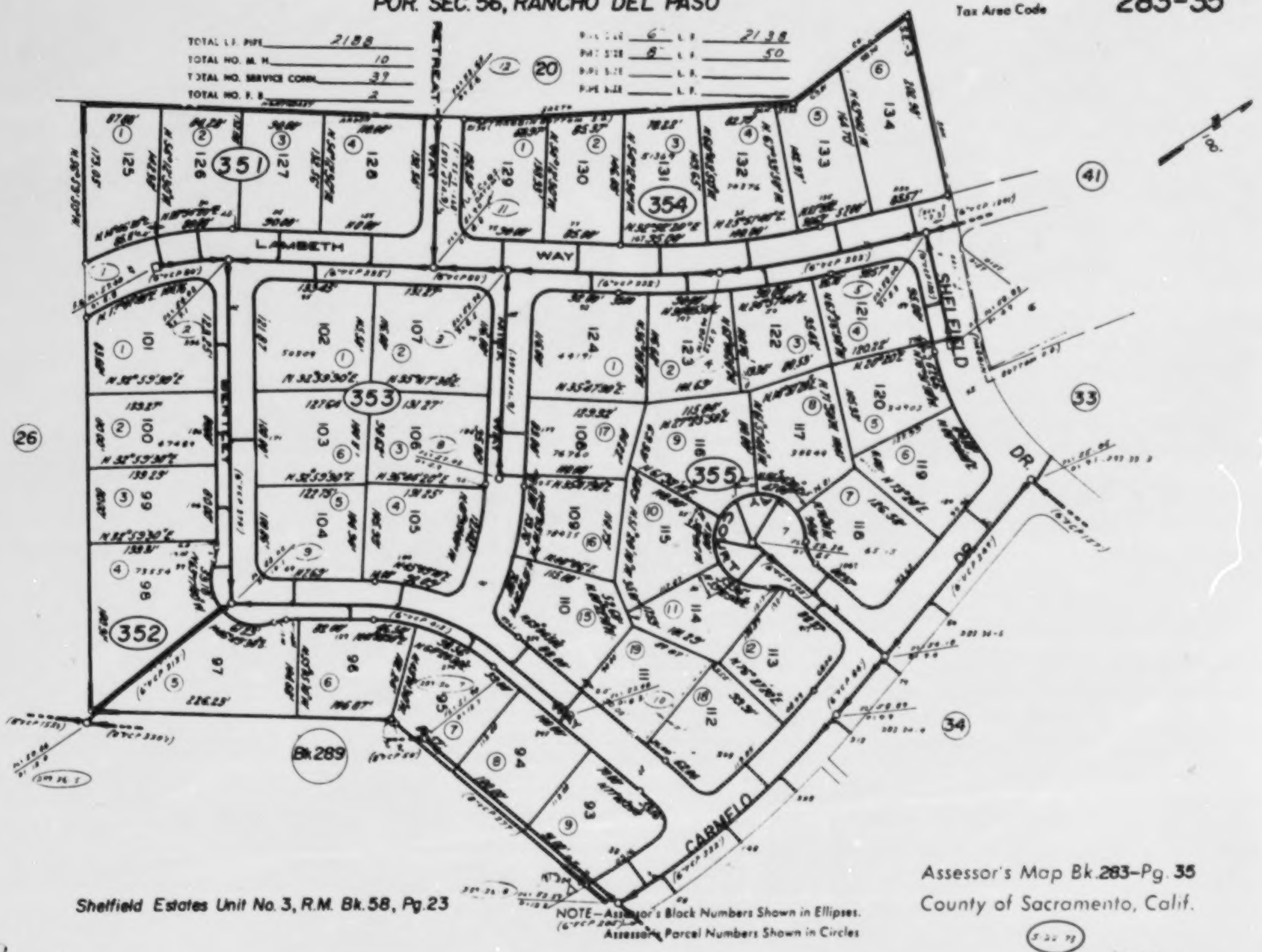

POR. SEC. 56, RANCHO DEL PASO
Tax Area Code
283-35
TOTAL L.F. PIPE 2188
TOTAL NO. M. H. 10
TOTAL NO. SERVICE CONN. 39
TOTAL NO. F. H. 2
RETREAT WAY
LAMBETH WAY
BENTLEY
SHELFIELD DR.
CARMELO
COURT
351
352
353
354
355
20
26
33
34
41
Bk.289
Shelfield Estates Unit No. 3, R.M. Bk.58, Pg.23
NOTE—Assessor's Block Numbers Shown in Ellipses.
Assessor's Parcel Numbers Shown in Circles
Assessor's Map Bk.283-Pg. 35
County of Sacramento, Calif.

Fig. 10.5. Assessor's map

Scale: 1" = 100'
before reduction

LEGEND:

162	Block Numbers
14	Parcel Numbers
10	Adjoining Page
Bk. 255	Adjoining Book
5	Lot Numbers
5	Manhole Numbers
242-10-30	Manhole shown on another page
86761	Connection Permit Numbers

Fig. 10.6. Assessor's map numbering legend

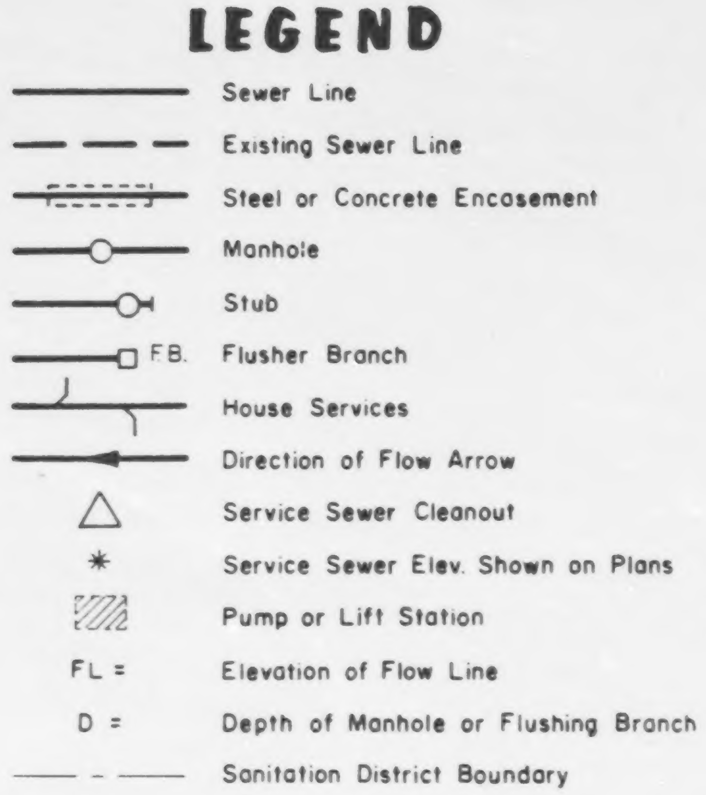
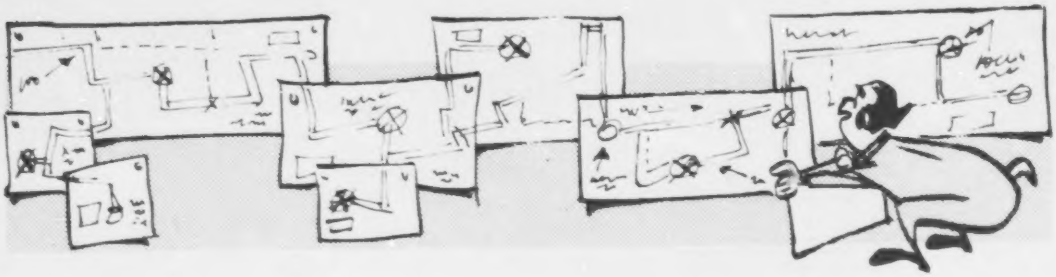

LEGEND
Sewer Line
Existing Sewer Line
Steel or Concrete Encasement
Manhole
Stub
F.B.
Flusher Branch
House Services
Direction of Flow Arrow
Service Sewer Cleanout
Service Sewer Elev. Shown on Plans
Pump or Lift Station
FL =
Elevation of Flow Line
D =
Depth of Manhole or Flushing Branch
Sanitation District Boundary

Fig. 10.7. Assessor's map symbols

10.14 Importance of Updating

To remain functional a mapping system must be kept as current as possible. Accurate and up-to-date maps can reduce time consuming and costly mistakes. Suggested methods of accomplishing this are:



A. Changes in collection system. When new sections of sewer, manholes or other structures are built and placed in service, update maps to show new facilities. If sewers or structures settle, slip sideways or tilt, they must be repaired and restored to original location. Record any changes made during repairs to make facility operate better or installation more stable.

B. Annually. Updated maps should be reprinted at least once a year. Reprinting more often than on an annual basis would probably not be economically feasible. However, the process of gathering information needed for the annual reprinting, should be a continuous one and conducted throughout the year as suggested below.

C. Recording changes.

   1. With tracings. When tracings are available, changes should be recorded on the tracings as soon as they occur throughout the year.

   2. Without tracings. A suitable method of recording and filing changes as they occur, should be implemented and maintained throughout the year. All

corrections should be attached to a map so they will be readily available when needed. Changes can then be made when the time comes for updating and printing of maps.

D. Mapping personnel. A mapping system of any significant size will require trained personnel responsible for keeping it current and accurate. A definite system of funneling information, relative to map changes, to mapping personnel should also be established and maintained. Good drafting personnel are essential and management must make sure that all changes are recorded as soon as possible on the maps.

E. Field workers. Even in the most efficient map updating programs, some changes will be overlooked or unreported. This will happen primarily due to the scope of the many details to be covered and the vast number of people involved. Field workers can help in the following ways:

1. Collection system workers. As the primary users and chief benefactors of a good mapping system, maintenance workers can be easily trained to report any discrepancy they encounter in their daily activities. Supervisors should develop a specific system, with appropriate forms, to insure these reported changes are promptly forwarded to the mapping section.

2. Inspectors. During initial construction many changes occur and unusual conditions are encountered in the field. Inspectors should be instructed and required to note such information on their "as built plans". This information can be included in any future updating of maps.

Management must encourage accurate reporting by both collection system workers and inspectors.

F. Field checking. If you have no formal system or set schedule for updating maps, periodic field checking may be practical. Field checking can be accomplished by properly trained field service request crews during periods with few service requests on a fill-in basis and will be beneficial, especially in smaller collection systems.

QUESTIONS

10.1G Which type of map contains the most details regarding a wastewater collection system?

10.1H Why should maps be updated?

10.1I How can maps be kept up to date?

10.15 Maps as Maintenance Records

In some instances maps can provide an excellent method of recording maintenance activities.

A. Small collection systems. Sufficient workers may not be available to sustain an elaborate record keeping system. A separate set of maps kept in the office, for record purposes only, can be useful in recording the following:

   1. Problem areas. Color codes can be used to designate specific problems such as roots or grease.

   2. Maintenance activities. Dates, type of maintenance performed, areas involved and production footages can be easily recorded on these maps.

   3. Pins can be used to indicate repeated problems in specific areas.

   4. Schedules. Proposed maintenance schedules, including due dates, can be indicated for specific areas through the use of flags.

B. Medium size collection systems. Again sufficient workers may not be available to sustain detailed card record systems. A combination of card files and maps for records may be effective. Information adaptable for recording on maps might include:

   1. Area wide maintenance. Maintenance activities conducted on an area-wide basis can easily be recorded on maps through the use of color codes.

   2. Concentration of problems. Using colored pins to mark trouble spots, maps will show at a glance if problems are concentrated in one or more specific areas.

C. Large collection systems. Even in the largest collection systems it might be impractical to keep individual record cards on each individual section of pipe within the system. The number of cards required could make such record keeping undesirable. The cost and time required for posting daily activities on individual cards could be prohibitive. At the supervisor's discretion, a combination card and map record keeping system might be more practical and effective, for examples:

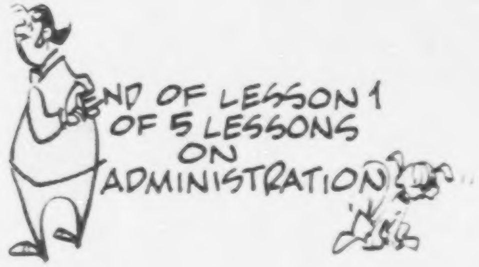
1. Master maps. When mounted on a wall, these maps would show at a glance where large scale maintenance programs had been completed. Again, concentrated or repeated problems would be quickly identified. Maintaining these maps over a five-year period on a yearly basis, by changing color codes each year, also would provide easy evaluation of the effectiveness of a particular program in any given area.

2. Assessor's maps or book maps. A complete set of these maps kept in the office will provide an excellent place to quickly record daily production footages. Their large scale provides ample space for recording date and particular type of maintenance performed on each individual section of pipe line. Using different colored pens for each maintenance cycle, there also is ample room to record maintenance activities over a five-year period. One individual should be assigned the responsibility of keeping such records accurate and current. Also, when used for this purpose, map books become permanent records and should be safely stored in a locked cabinet. For obvious reasons, they should never be accessible to maintenance crews for field use; however, copies can be made of these maps for use by field crews.

QUESTIONS

10.1J How can maps be used as a maintenance record?

10.1K How can problem areas be shown on a map?



DISCUSSION AND REVIEW QUESTIONS

CHAPTER 10. ADMINISTRATION

(Lesson 1 of 5 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in the lesson. Write the answers to these questions in your notebook before continuing.

1. Why are good maps needed for wastewater collection systems?
2. What information must be included on wastewater collection system maps?
3. Discuss the advantages of identifying the location of important points of underground utilities on a grid coordinate system.
4. Why do utility agencies use different types of maps (master, section and assessor's maps)?
5. What can happen if maps are not kept up to date?

1222

CHAPTER 10. ADMINISTRATION

(Lesson 2 of 5 Lessons)

10.2 RECORDS

From its start, a collection system will begin to generate records. The variety of records to be produced is unlimited. Size of the collection system, scope of activities, variety of programs, and the desires of supervision and management, all will have an influence on the volume and detail of the records that are produced. Supervisors will find their personal involvement with actual record keeping will vary in relation to the size of their particular collection system.

The supervisor of a small collection system may be directly involved in the day-to-day record keeping activities of all aspects of the operation. In fact, the supervisor may be personally responsible for the preparation of many of the required records. The supervisor will certainly assume more active participation in the decisions as to what type of records are needed and on what form they are to be recorded.

The supervisor of a large collection system may encounter entirely different circumstances. Larger organizations will have more sophisticated record systems, with record keeping processes and policies that have been set up by specialized accounting sections. The supervisor may be responsible only for the administration of these processes and adherence to set policies.

Records pertinent to collection systems cover a wide range of needs and activities. Cost accounting, personnel, production, payroll, and history are just a few examples of major concern. For the purpose of this section, we will place our emphasis on records that are of operational interest.

10.21 Need for Records

In general, records fill two basic needs. They record the past and provide a sound basis on which to plan the future. To meet these needs, records will have to be maintained on almost every activity and event that occurs in the daily operation and maintenance of the collection system. Some major areas of importance are:

10.211 Costs

Costs must be of prime concern to all maintenance supervisors. It is not enough that the supervisor maintain the system to a high degree of efficiency -- the supervisor also is accountable for the costs involved.

A. Labor. Time sheets, time cards, payrolls, time reporting, are all of vital importance to each of us. We all want to be paid. Every supervisor should be particularly attentive to the accuracy, completeness, and punctuality of time reporting. The supervisor too wants the workers paid accurately and on time. Delayed or inaccurate paychecks do little to improve employee morale.

B. Equipment. As with labor costs, accurate reporting of daily use of equipment also is necessary.

C. Supplies. Distribution, consumption, and use of materials must be accounted for accurately. Supplies usually are obtained from two sources; outside vendors and in-house stores. Special attention should be given to efficient handling of hand tags, bills and statements generated by purchases from outside vendors. They also expect to be paid promptly. Maintaining good relations with these vendors can come back as a direct benefit to a supervisor when an emergency occurs and the supervisor is in need of a speciality item in a hurry.

D. Services. Many maintenance organizations do not have the necessary equipment or adequate staff to complete all their required activities. Certain aspects of their work may require specialized equipment, or have an infrequent need factor. Such work might be more economically performed by other than in-house staff.

From an operational standpoint, it is important to maintain close accounting of the cost of these outside services. A significant increase in volume of these services could indicate that it would be more economical to acquire the necessary equipment and/or staff needed to perform such work in-house.

10.212 Basis for Maintenance Programs and Schedules

A maintenance schedule or program should be designed to combat or eliminate certain conditions that are known to exist within a collection system. Adequate records are required to locate and identify these areas and conditions that are in need of scheduled maintenance procedures.

The many types of records and necessary forms needed to provide this information are covered in detail in Section 10.22, Types of Records.

10.213 Budgeting

At budget time records become of prime importance to a supervisor. Accurate records detailing last year's activities, costs, work load, growth, and production are the best justification for next year's budget requests. Prepare budget and programs to meet the needs of the community and accomplish the objectives of the agency. Document that collection system programs are as important as the programs of other agencies with which you are competing for funds.

A. Staffing. Requests for increased staffing are one of the most difficult budget items to justify to the satisfaction of management. Rarely does management accept a request for more staff that was based solely on the opinion or experience of the supervisor, regardless of the supervisor's competency.

   Accurate records can provide the necessary justification for additional staff. Analysis and presentation of records covering several years can indicate a definite trend in your activities. They can verify that your work load had increased to a point that makes additional staffing essential and justified.

Another possible approach for the preparation and justification of budgets is to compare your situation and program with staffing guides developed by the U. S. Environmental Protection Agency and other responsible sources. Be sure to document your situation and compare your program with communities that have similar situations.

B. Equipment additions and replacement. As with staffing, these items must also be justified at budget time.

Age alone is not always the determining factor as to when equipment should be replaced. Production and utilization records for each piece of equipment may be used to substantiate replacement. Maintenance costs required to keep equipment operational will be another important factor to be considered in justifying replacement.

Additional equipment often is required for use by additional staffing. One will usually justify the other. Often the need for newly developed equipment to cope with a specific condition will become apparent. Here again the best justification may be found in your records.

C. Supplies. Past requirements and consumption based on records will provide the most accurate indication of future needs.

D. Services. Budget time is when you should carefully analyze past expenditures for outside services. Your records could indicate they have increased to a point where it would be more economical to acquire staffing and equipment needed to perform such work in-house.

RENT A WORKER
$
$
$
$

E. Analysis of Records. Good records can be easily analyzed and the results of analysis presented in tables, charts or graphs. These results often show or illustrate a budget need very effectively. To illustrate this point, let's examine an actual example of how Sacramento County justified the budgeting of an additional high velocity cleaner and crew.

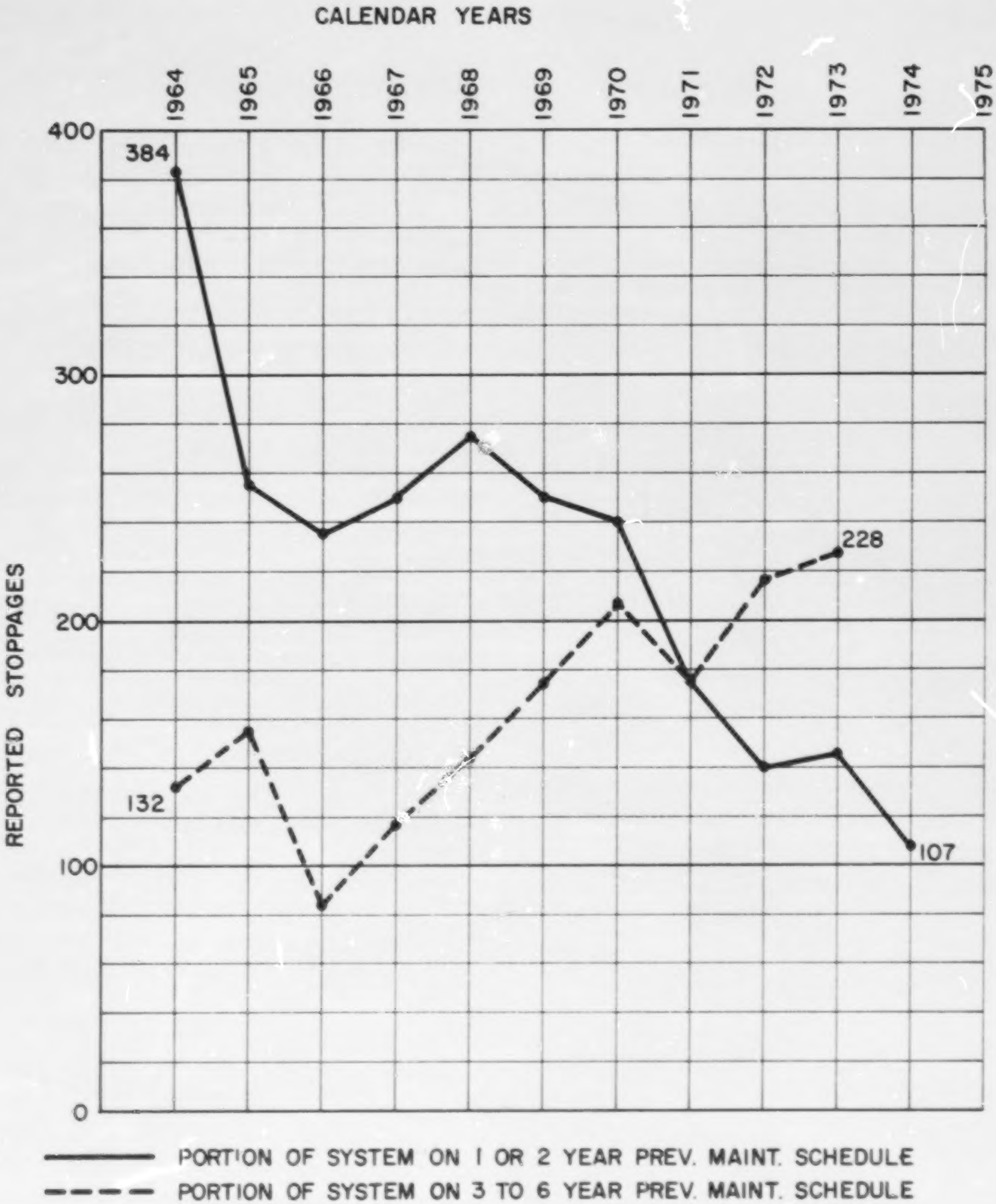
The wastewater collection system was divided into two portions for the purpose of developing a preventive maintenance schedule (Section 10.312). One portion of the system was on a one or two-year schedule while the other portion was on a three to six-year preventive maintenance schedule. The worst areas were included in the one to two-year schedule. Results from an analysis of records were plotted as shown on Figure 10.8.

An examination of Figure 10.8 shows that the portion on the one or two-year schedule had a significant reduction in the number of stoppages, but the portion on the three to six year schedule was experiencing an alarming increase in the number of stoppages.

What caused the increasing number of stoppages? Certainly the frequency of cleaning is one answer. Were the stoppages caused by grease, roots or other problems? The answer to this question reveals the type of equipment and/or necessary adjustments in the preventive maintenance schedule. Most of the area where the increases in stoppages occurred was in thinly populated areas with large lots. Grease accumulation was the main cause of stoppages.

How can the number of grease stoppages be reduced? One more high velocity cleaner would allow Sacramento County to place almost the entire wastewater collection system on a two year or more frequent preventive maintenance schedule as needed.

This pictorial analysis of results and logical analysis of the problem and proposed solution can be a very effective means of justifying your budget.



NOTE: STOPPAGES REDUCED FROM 384 TO 107 ON 1 AND 2 YEAR SCHEDULE.
STOPPAGES INCREASED FROM 132 TO 228 ON 3 TO 6 YEAR SCHEDULE.

Fig. 10.8. Trends in number of stoppages in Sacramento County

10.214 Legal Aspects

Legal problems represent a very important reason for maintaining good records of daily activities. Unfortunately, at any time, agencies responsible for operation and maintenance of collection systems may become the target of legal action or liability claims. The best defense is reliable records to verify that standard procedures were followed and that you were not negligent in meeting your responsibility. Records of complaints must be recorded along with investigative action taken and corrections made. Times, dates, who was contacted and who did what are essential. If no records were prepared, this may be a basis for a negligence suit.

A. Law suits. As operators of collection systems, it is our responsibility to maintain these systems with minimum hazards to public health and safety and provide continuous service. In recent years court decisions have gone against public agencies that failed to fulfill this responsibility.

In event of such legal action, your records are certain to be examined in minute detail. Routine items such as dates, times, and identification numbers, will suddently become legal evidence as to your actions or inaction. It is very important that you set up a system to check and double check these routine items on the hundreds, or thousands, of record cards generated throughout the year before they are filed to become a permanent legal record.

B. Liability. The nature of our work exposes us to direct contact with the public and their private property. The public, in turn, will have daily contact with appurtenances of our collection systems which are in public right of ways. All these contacts provide many opportunities for either damage to private property or injury to the public through contact with a defective part of our system.

Aside from the fundamental necessity of exercising appropriate care and consideration while on private property and keeping our collection systems free of hazards, there is another thing we must do. We must keep adequate records to document our daily routines to a degree that will be of value in establishing our innocence or disprove any negligence on our part should such liability claims arise.

QUESTIONS

10.2A List the two basic reasons for collection records.

10.2B Records should be kept on what different cost items?

10.2C How can good records be helpful to persons preparing a budget?

10.2D Discuss the legal aspects of record keeping.

10.22 Types of Records

There are so many different types of records and special forms that can be useful to maintenance organizations that space will not allow detailed discussion of all of them in this section. Only a few of the most common will be presented or illustrated. With these examples you can prepare forms to meet your own special needs.

10.221 Personnel

Records relative to personnel are common to all organizations.

A. Personnel file. Such a file should be maintained for each individual employee. An important part of this file would be an individual fact sheet. This sheet should provide such information as: age, blood type, innoculations, dependents, and medical history for use in case of accident or serious injury. This file must be kept up to date and include accidents, sicknesses, training and new skills learned.

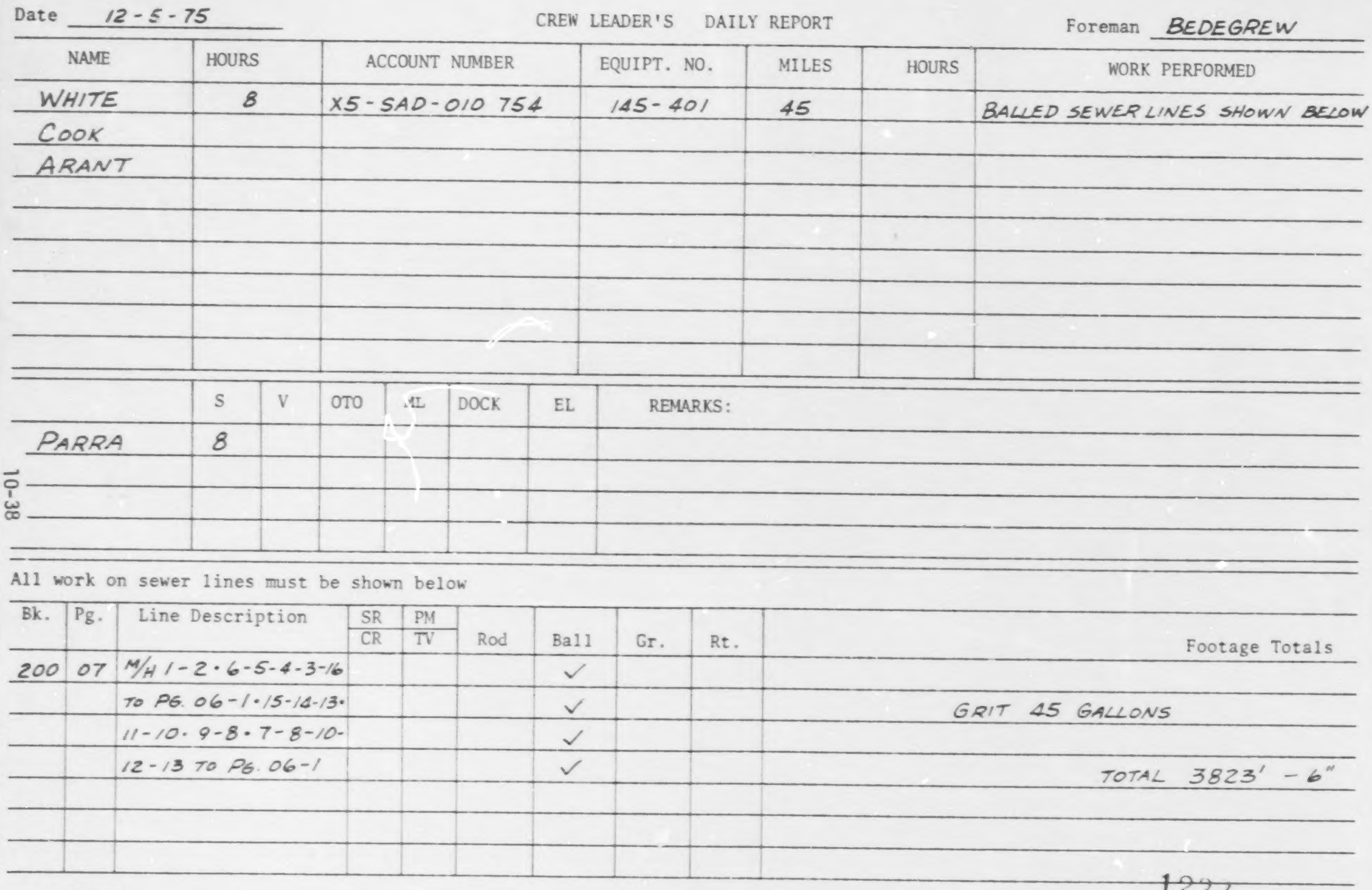
General information contained in this file may include work history, commendations, disciplinary actions, attendance records, performance evaluations, and training courses.

B. Daily assignment sheet. Assignment sheets can be designed to provide an accurate record of many daily activities. Much of this information can be posted on other record cards to become part of the permanent record file.

The example in Figures 10.9 and 10.10 is very functional. The following information can be recorded:

On the front side (Figure 10.9, Crew Leader's Daily Report)

1. Date
2. Foreman in charge
3. Crew leader
4. Individual crew members



Date 12-5-75

CREW LEADER'S DAILY REPORT

Foreman BEDEGREW

NAME	HOURS	ACCOUNT NUMBER	EQUIPT. NO.	MILES	HOURS	WORK PERFORMED
WHITE	8	X5-SAD-010 754	145-401	45		BALLED SEWER LINES SHOWN BELOW
COOK						
ARANT						

	S	V	OTO	ML	DOCK	EL	REMARKS:
PARRA	8						

10-38

All work on sewer lines must be shown below

Bk.	Pg.	Line Description	SR CR	PM TV	Rod	Ball	Gr.	Rt.	Footage Totals
200	07	M/H 1-2·6-5-4-3-16				✓			
		TO PG. 06-1·15-14-13·				✓			GRIT 45 GALLONS
		11-10·9-8·7-8-10-				✓			
		12-13 TO PG. 06-1				✓			TOTAL 3823' - 6"

Fig. 10.9. Crew leader's daily report

DAILY JOB SHEET

DATE 12-5-75 FOREMAN BEDEBREW

CREW LEADER WHITE

COOK

ARANT

JOB ASSIGNMENT - LOCATION	LEAVE YARD	ARRIVE JOB	BREAKS & LUNCH	FINISH JOB	ARRIVE YARD	
BALL BOOK 200 PAGES 5, 6, 7, 8	7:30	7:50	9:30 – 9:45 COFFEE			
ELKHORN BLVD. AND RAMSEY			11:30 – 12:00 LUNCH			
			1:30 – 1:45 COFFEE	3:00	3:20	

REMARKS

Fig. 10.10. Daily job sheet

5. Complete daily assignments, including geographic location and identification numbers of specific work areas

6. Travel time, related time spent in traveling to and from several job locations

7. Equipment numbers and charges, in miles or hours, also can be noted by separate cost account numbers

8. When crew members are absent, list their names and reasons (Figure 10.9, Parra, 8 hours of sick leave). On the form shown, the following symbols are used:
   S - Sick, V - Vacation, OTO - Over Time Off,
   ML - Military Leave, DOCK - Dock or no pay,
   EL - Emergency Leave. Any additional information goes under REMARKS.

9. Work accomplished on sewer lines is described by identifying the area by book number (Bk), page number (Pg), and by line description (manhole numbers).

10. Type of work done is identified by service request or complaint request (SR/CR), preventive maintenance - television inspection (PM/TV), rodding (Rod), balling (Ball), grit removal (Gr), root treatment (Rt). Additional helpful information is recorded such as volume of grit removed and any special conditions or problems encountered.

11. Total footage is recorded too.

By placing carbon paper and a 5 x 8½ sheet of paper under the left hand half of this front side, the foreman can retain a copy of the day's assignments. This copy will remain in the office to provide ready reference to each crews location throughout the day.

On the reverse side (Figure 10.10, Daily job sheet)

1. Record date and names of foreman, crew leader and other crew members.

2. Identify the job assignment by location. Describe location by map or book number and pages and also describe location by street names.

3. Record time leave yard, arrive at job, for breaks, for lunch, finish job and arrive at yard.

4. Record this information for each individual job requiring a separate cost account number.

5. Provide any remarks that might be helpful in explaining time to do job or travel times.

This type of record is quite complete within itself. When accurately and completely filled out, it can be filed as a permanent record.

10.222 Equipment records and forms are fairly standard.

A. Utilization report. An accurate, complete, daily report of equipment use should be made at the end of every job. Automotive equipment is commonly reported on a mileage ticket. This ticket will allow for reporting total mileage and distribution of mileage by separate cost account numbers if necessary.

Construction equipment or specialized equipment is reported by hours on a separate ticket for each piece of equipment. Provisions should be made for the distribution of hours by cost account numbers. How detailed your records must be depend on area served and method of accounting.

10.223 Logs

A written record of contacts with the public or service requests (complaints) (Section 10.224) also should be kept.

A. Telephone logs. A common practice is to maintain a written log of all telephone calls as they are received. This is especially applicable to calls from the public which require some action or response by the maintenance organization.

CALL DRK. FOR APPT TUES
WIFE LOAF OF BREAD 10⁰⁰ TUES
4TH & MAIN 9.45 AM FR CHARLEY
PHIL CALL PLANT 3
LLOYD 9⁰⁰ PM
OSCAR TWELVE 9.45 PM
PRATT
BRADY PLANT TWO 7.15
SIERRA

The log can be very simple. Information recorded should include:

1. Date
2. Time call came in
3. Name, address, and telephone number of caller. (It is important to obtain telephone number of caller so that they can be contacted if there is to be some delay or question in responding to their request.)
4. Nature of service request (complaint)
5. Time call was dispatched
6. To whom dispatched
7. Check mark, to indicate call had been carried to a completion.

This log is a very important record. Careful administration is a must regarding completeness and accuracy at all times. Little room is required for storage; and when completed, it should be safely stored under lock and key if necessary. In cases of legal action, this is one of the first records that will be requested for careful study.

B. Radio dispatcher's log. The need for this type of log will vary greatly with the size of the organization involved. Large organizations with many radio units and sophisticated equipment make tape recordings of all radio dispatches. Smaller organizations often combine the telephone and radio logs.

C. Other types of logs. Often records or diaries are referred to as logs. For example, you might encounter a foreman's log (diary), a lift station log or a pump log. See Section 10.227, Miscellaneous Records, for types of records that might be called logs.

QUESTIONS

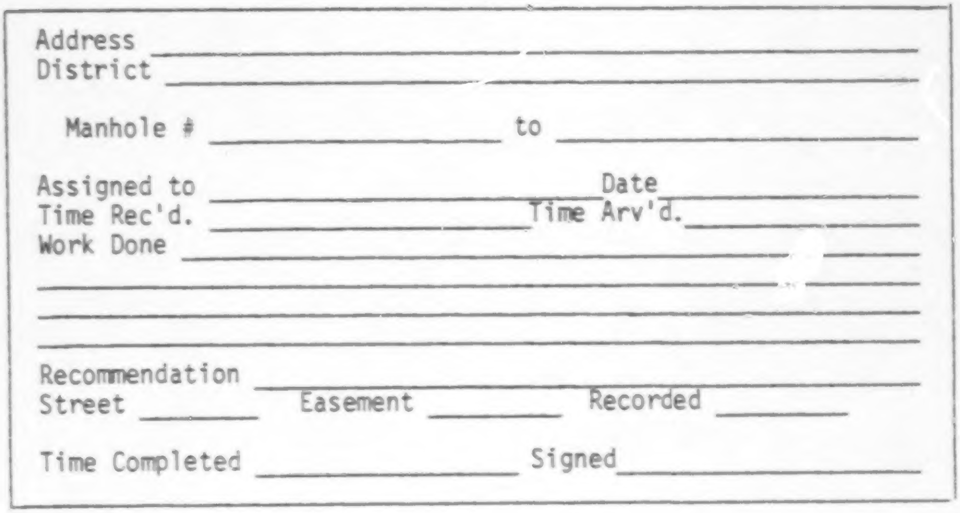
10.2E What kind of information should be contained on an individual's fact sheet in a personnel file?

10.2F What types of logs should be kept? Why?

10.224 Report of Service Request

Nearly all maintenance organizations will use this type of record in one form or another. Size, routing, information included, and filing procedures may be tailored to fit the requirements of each individual organization.

For an example of a simple, functional card of this type, see Figure 10.11.



Address ______________________________

District ______________________________

Manhole # ______________ to ______________

Assigned to ______________ Date ______________

Time Rec'd. ______________ Time Arv'd. ______________

Work Done ______________________________

____

____

____

Recommendation ______________________________

Street ________ Easement ________ Recorded ________

Time Completed ______________ Signed ______________

Fig. 10.11. Card for reporting service request

The information on this card has been purposely limited to important essentials. This was done for the purpose of keeping the card small. Its actual size is 3" x 5", which makes it possible to file many of these cards in a small space. All completed cards are placed in a permanent file to be kept indefinitely. Note that the name of the person living at the address and the phone number are not on the card. People living in the house move and phone numbers change, but the problems in the sewer always can be located by the house address. Main line problems are located by distances between manholes.

We have shown only the front side of the card. The reverse side can be used to provide whatever additional information might be required, such as conditions encountered upon arrival at the job site.

These cards should be turned in to the foreman at the completion of each day's shift. Accuracy and completeness of cards must be verified. The foreman also will approve and assign any follow-up work indicated in the recommendation.

A good public relations practice is to notify the person filing the service request of the action taken after the problem is corrected. Figure 10.12 shows a typical letter sent to a property owner who has filed a service request and a post card for the customer's response regarding the service received.

10.225 Follow-Up Work Order

Some form of this type also is used by many maintenance organizations. Again, the physical make-up of the form will vary with the particular needs of each organization. They can be prepared in single, duplicate, or any required number of copies. An advantage of duplicate or carbon copies is that the original copy can be retained in the office as a check to verify that the duplicate copies in the field are returned and properly filled out when completed. For an example of a simple work order form, see Figure 10.13.

AGENCY LETTERHEAD

Dear Customer:

According to our records, one of our crews was recently dispatched to your property regarding a sewer problem.

In order to improve our services, we would appreciate your appraisal of our service by completing the enclosed card and returning it to us at your earliest convenience. We especially invite your honest and sincere comments.

Thank you for taking time to help us improve our services to you.

Very truly yours,

Walter L. Driggs, Superintendent
Water Quality Division

	Yes	No
Did the operator handle your call in the expected manner?	☐	☐
Did we respond to your call within a reasonable length of time?	☐	☐
Was the Crew courteous and sincere in their efforts in solving your problem?	☐	☐
If the Crew worked in your yard, were they considerate of your property?	☐	☐
Did the Crew explain to you the County Policy regarding your particular problem?	☐	☐

Your comments: ....

....

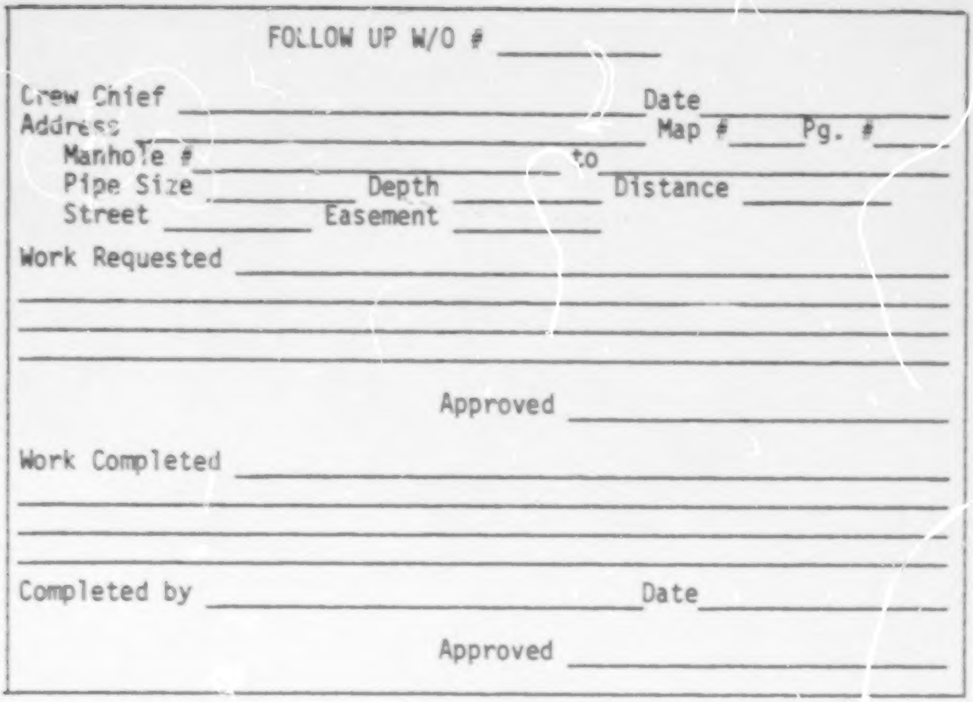
....

....

....

....

Fig. 10.12. Letter to customer who complained and post card for response



FOLLOW UP W/O # ________

Crew Chief ______________________ Date __________
Address ______________________ Map # _____ Pg. # _____
Manhole # ______________ to ______________
Pipe Size ________ Depth ________ Distance ________
Street ________ Easement ________

Work Requested ______________________________
____
____
____

Approved ______________

Work Completed ______________________________
____
____
____

Completed by ______________________ Date __________

Approved ______________

Fig. 10.13. Work order form

Here again the information has been limited to essentials in the interest of keeping the form small. Actual size is 4" x 6". Each of these completed forms is filed as a permanent record of work done to a particular section of line. Over the years thousands are placed in such files and space is an important consideration.

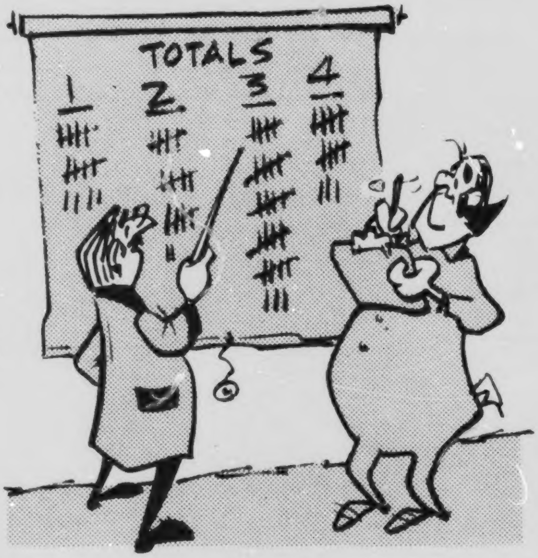
Only the front side of the form is illustrated. Many organizations desire to keep time, equipment, and materials costs on these work order forms, the reverse side provides ample space for that information.

An important point should be mentioned relative to the simplicity of the forms we have illustrated. Many such forms are designed with numerous notations and boxes provided to cover almost any possible procedure or activity to be performed. Such forms are cluttered. In actual practice only a very small percentage of the boxes provided need to be checked for each particular job. This makes reviewing the forms for completeness difficult.

10.226 Production Records

Continuous accounting of production must be carried on throughout the year.

A. Daily production figures are available from all the maintenance forms we have illustrated. The foreman should enter these daily figures for each of the crews on the monthly report.



B. The foreman's monthly report should include such totals as:

   1. Total number of service requests received and responded to.

   2. Above total for each crew (emergency crews only).

   3. Total main line stoppages. This total also should be broken down into categories such as roots, grease, and other debris. Number of odor complaints and other problems should be listed too.

   4. TV inspection footage, by individual crews.

5. Balling footage, by individual crews.

6. Rodding footage, by individual crews.

7. High velocity cleaner footage, by individual crews.

8. Main line repairs.

9. Manholes, elevation adjusted and/or repairs.

These are but a few of the main activities common to most organizations. The list can be expanded to include any activity you wish to keep accurate accounting of.

Individually these monthly reports may not appear significant. However, if you follow this procedure over a period of years, they become very important as a means of analyzing both your production and variations in your work load in specific areas.

C. Annual reports. These may be simply the annual total of your monthly reports. They may or may not be broken down to reflect totals for individual crews. Annual reports should reflect totals of specific activities such as balling and rodding in relation to specific areas within your system.

10.227 Miscellaneous Records

We have only discussed, in some detail, a few record forms common to many collection system operations. Other records to be kept might include:

A. Diaries. A diary will provide an excellent method for foreman and crew leaders to record a variety of unusual happenings or information which may occur and for which no other reporting form is provided.

B. Other. In name only, here are a few more reports we may be concerned with:

1. Accident reports - personal injury and vehicle

2. Flooded home reports (sewer back-up)

3. TV inspection logs.
4. Vehicle inspection slips (monthly).
5. Tailgate safety meetings.
6. Crew training.
7. Personnel actions.

QUESTIONS

10.2G List the information that should be on a card that records complaints.

10.2H Why should the person who filed the complaint be contacted after the problem is corrected?

10.2I When would you need to complete a follow-up work order form?

10.2J Why must forms be brief and simple?

10.2K What kind of information is kept in production records?

10.2L Why would a foreman or a crew leader keep a diary?

10.23 Responsibility for Records

Adequate forms can be designed to provide all the necessary information that could possibly be needed. This alone will not quarantee a good record keeping system. A functional record keeping system will place a degree of responsibility on all personnel involved.

10.231 Supervisor

This person is the one who will derive the most direct benefit from good record keeping. The supervisor should be the most concerned. Concerns should include:

A. What required. The supervisor should decide what records will be needed to meet job responsibilities. Control must be exercised over what amount of detail the records should include and which specific activities will require record keeping procedures.

B. Functional. Constantly be aware of the degree to which records are being used. Some records, after they are initiated, may become unnecessary because of changing conditions or policies. Any such records should be promptly discontinued.

C. Compliance. Throughout this chapter we have repeatedly used the terms accurate, complete, current, and adequate with reference to good record keeping. A supervisor should be constantly alert to the adherence to these terms by the workers in their daily compliance with record keeping policies.

10.232 Field Workers

A majority of operational records will originate in the field at the hands of field workers. They must understand their responsibility for the following aspects:

A. Accuracy. Once involved in a meaningful record keeping program, you will repeat this word many, many times. Records must be accurate. One digit in an address or identification number when ommitted, unreadable, or reversed can make a record card practically useless.

B. Neatness. A constant cause for concern with field workers. Adverse working conditions and wet weather often make legible record cards difficult to produce. Excuses for illegible cards are often valid. Field crews should be allowed ample time and proper facilities to allow them to complete and turn in neat records.

C. Promptness. Field crews often develop a habit of completing their records at the end of the day. This is especially true when crews complete a day's work at several different locations. The most effective method of completing a record card is at the scene of the job when all the facts and circumstances are available and obvious.

D. Compliance. Field crews can and will comply with the foregoing standards. Much of the information recorded on these cards will benefit field crews doing future follow-up work. Field crews understand this and appreciate the value of good records. A supervisor should never accept less than full compliance with the above standards. Field crews will soon realize the concern with accuracy is for their benefit, and they will begin to take pride in their individual record keeping habits. Praise crews when they do a good job and ask for additional information when they forget essential information.

10.233 Office Personnel

The ultimate destination of most records is with office personnel. They should cooperate in:

A. Filing. Records need to be filed in such a manner as to provide information quickly to workers in the field. Filing should be maintained as current as possible, on a daily basis if possible.

B. Familiarity. Office personnel must become familiar with the nature of our field work. It will help them to understand the importance of our records and will greatly improve the cooperation between office personnel and field workers.

10.24 Value of Records

The value to be placed on records may vary with the degree of responsibility held by the various people who depend on those records.

10.241 Supervisor

Throughout this section of this chapter we have explained the reliance placed on records by a supervisor. Without them there is little chance that a supervisor could perform effectively. Often the supervisor is not present, so crew reports must serve as the ears, eyes, hands and head of the supervisor.

All supervisors at some time will be called upon to justify their operations and their programs. The supervisor of a collection system soon recognizes a handicap not shared by counterparts in other fields. A street supervisor can point to newly paved streets. A plant or building supervisor can show off freshly painted or remodeled buildings. A park supervisor can point to improved landscaping. A year of collection system maintenance, be it 100 miles or 1,000 miles, looks exactly the same on the surface as before the program was completed. Adequate records demonstrating improved performance are the collection system supervisor's only yardstick. Complaint records and the responses to them are often the best documentation available of the job done by the crews. Good public relations demand that complaints be handled promptly and effectively.

10.242 Field Workers

Field workers appreciate the fact that records provide a means of reporting their individual daily performance. A complaint from the public relative to tardy, incomplete or unsatisfactory service in most cases will be proved invalid by the facts on the record card indicating time involved, amount of work done, and compliance with maintenance policies.

10.243 Management

Being farther removed from the operational concerns of day-to-day maintenance activities, management may place different values on good records. They require facts on which to base their decisions. If these facts are available through good record keeping, it creates confidence in the maintenance organization.

QUESTIONS

10.2M Who is responsible for being sure your agency has a good record keeping system?

10.2N What is the value of good records to supervisors?

10.3 SCHEDULING MAINTENANCE

Collection systems are designed to transport wastewater without interruption to disposal sites or treatment plants. Most of these collection systems were designed to be "self-cleaning". Experience has shown otherwise for many collection systems. As time passes, various conditions develop which interrupt flows and diminish design capacities and efficiency of these collection systems.

Inadequate maintenance procedures have resulted in overflows or discharges of polluted wastewater into streams, streets, right of ways, rivers, and private property. Supervisors have been able to excuse these conditions as "unavoidable accidents", "acts of God or nature" or lack of sufficient capacity within their systems. Today, environmental concerns and regulatory agencies will no longer accept these excuses or tolerate these conditions. Also the public accepts fewer inconveniences and demands to know what went wrong and why.

The responsibility for elimination of these conditions rests squarely on today's collection system supervisors. They must realize that they can influence the performance of the collection system. Through the use of modern, specialized maintenance equipment and well planned maintenance scheduling, the supervisor can develop meaningful maintenance programs that will minimize or eliminate these undesirable conditions.

10.31 Types of Maintenance

Although there are many types of maintenance and many different thoughts regarding what is a good maintenance program, let's try to think in terms of what needs to be done. A good maintenance program tries to prevent stoppages, failures, and complaints. This program tries to anticipate what is going to go wrong and prevent it from happening. If something goes wrong, the problem is identified and corrected or repaired. With these ideas in mind, let's try to schedule maintenance crews on the type of maintenance job they are doing.

10.311 Emergency Maintenance

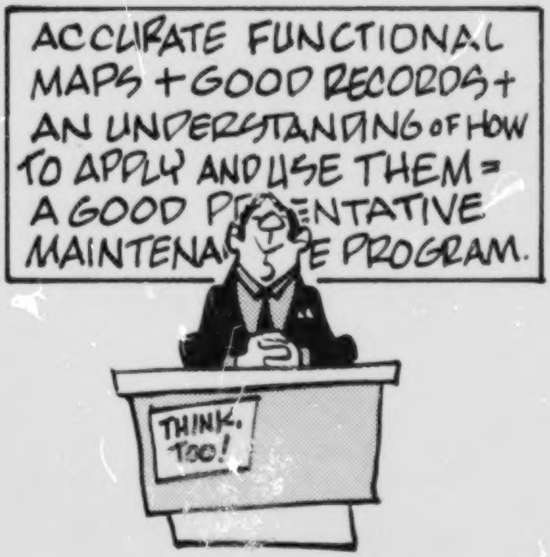
Even with all our modern equipment and sophisticated maintenance programs, emergency maintenance is still a basic service provided by maintenance organizations. With a well trained and equipped crew, emergency service can be very efficient. When emergencies do arise, generally they are handled swiftly and with little or no inconvenience to the public served. Major structural damage from earthquakes or accidents and the collapse of pipes from corrosion damage usually take a little longer to restore service.

Naturally we cannot schedule emergency maintenance. We can only staff to handle it quickly and effectively. As our preventive maintenance scheduling techniques develop and improve, the need for emergency maintenance will be constantly decreasing.

10.312 Preventive Maintenance

Preventive maintenance is the most effective and efficient type of maintenance program. This type of program should not be designed merely to prevent problems or simply to make it possible for us to live with problem areas.

Preventive maintenance should be a total concept including all the aspects of this chapter. A good preventive maintenance program requires a supervisor that knows what is likely to happen and where. The supervisor needs accurate, functional maps, good records, and an understanding of how to apply and use them. Intelligent use and assignment of available staff and equipment is important as well as properly planned and meaningful maintenance scheduling. All these aspects, properly applied, will provide a true preventive maintenance program.


ACCURATE FUNCTIONAL MAPS + GOOD RECORDS + AN UNDERSTANDING OF HOW TO APPLY AND USE THEM = A GOOD PR ENTATIVE MAINTENA E PROGRAM.
THINK, TOO!

An effective preventive maintenance program provides the supervisor the ability to: "Apply effective preventive and corrective maintenance procedures over a controlled time period which will keep the collection system operating as intended with a minimum of stoppages or failures." Let me repeat that again in more simple terms. "Improve existing conditions in problem areas to a point where scheduled maintenance can be significantly reduced or ultimately reduced to the absolute minimum."

The program allows the supervisor to manage the collection system, rather than have the collection system manage the supervisor. The program is effective, efficient, and economical. The results to be achieved can become a matter of pride to all workers involved in making such a program work -- from the supervisor down to the collection system worker in the manhole.

QUESTIONS

10.3A How can overflows or discharges of polluted wastewater into streams, streets, right of ways, rivers, and private property be minimized or eliminated by wastewater collection system maintenance programs?

10.3B What is a preventive maintenance program?

10.32 Basic Aspects of Scheduling

To formulate an effective schedule for maintaining a collection system can be very difficult. Scheduling is complex, not necessarily in a technical sense, but more because of the many varied facts and details that must be considered. There are no short cuts to good scheduling. Maintenance of a collection system is an ongoing process which often spans years of past history, and which must consider future years of anticipated growth and increased loadings on collection systems. It is difficult to list all the many details to be encountered in planning a maintenance schedule. Some basic details to be concerned with are described in the following section.

10.321 Knowledge

This is the name of the game. Without it, there is little chance for the schedule to be effective. The knowledge needed is not necessarily relative to anyone's intelligence or IQ. The required knowledge will be more relative to the following:

A. Collection system. You must have a thorough knowledge and understanding of your collection system. You will need to know the nature of your problems and the areas in which they are concentrated.

There are various ways of acquiring this information. A great deal of it may come to you through experience and familiarity with your collection system. The most reliable information could come from the facts stored in your records.

Aside from these obvious sources of information, there are other steps you can take:

1. Complete a comprehensive study of your system. Locate and identify the areas that are creating the most problems. After you have determined your problem areas, try to locate and identify specific problems.

2. A most effective method of identifying and locating specific problems is by selective inspection with closed circuit television cameras. Emphasis should be placed on the term "selective". Haphazard or random inspections with TV can be wasteful and inefficient.

   This practice can be used to survey even the smallest collection system. By careful pre-selection of troublesome areas, TV inspection can be contracted to be performed in an economical manner.

B. Maintenance procedures and equipment. Any schedule you plan will be influenced by, and perhaps tailored to, the procedures and equipment available to you. You should carefully evaluate these procedures and equipment. Elsewhere in this course you have learned that certain procedures and equipment are most effective when used to combat specific problems. Others may be effective to some degree in coping with a variety of problems. How are you using available equipment? Are you using it to its fullest potential?

10.322 Timing

Of vital importance to any schedule is proper timing. The very word "schedule" suggests timing. When planning maintenance schedules, two important time factors should be considered.

A. Only when needed. The ideal time schedule for maintenance would provide for completion of needed maintenance just prior to the development of any problems or emergencies. In actual practice this is virtually impossible to attain. It is in fact, however, what we should be striving to achieve to the greatest degree possible.

B. Too frequent. If there is one weakness common to many maintenance schedules, this would be it. In their efforts to foresee and forestall the development of emergency situations, many supervisors are prone to scheduling maintenance too frequently. This approach cannot be considered to be totally wrong. It is the lesser of two evils, the other being an inadequate schedule which results in too little maintenance. At best, however, too frequent maintenance must be considered inefficient. It is inefficient from an economical standpoint and it ties up workers and equipment that could be used more productively in other areas where maintenance is needed.

10.323 Adjusting Schedules

A good maintenance schedule should be flexible. Periodically it should be revised in accordance with the results it has or has not produced.

A. Objectives. When an area or section of line is assigned to a maintenance schedule, it should be with an objective in mind. Will the scheduled maintenance eventually eliminate the problem? Will the scheduled maintenance merely control the problem to a degree that is acceptable? After five years of scheduled maintenance, is there any significant improvement evident? If not, what is the next step?

B. Effectiveness. When a schedule has been designed with an objective in mind, it is possible to measure the effectiveness of that schedule by the degree to which you have achieved your objective.

Table 10.1 indicates the history of stoppages in various areas that were on a preventive maintenance program for an eleven-year period. (Table 10.1 is plotted on Figure 10.8.) We have used stoppages as a means of weighing the results of this program because they are a tangible change that can be actually counted and shown on a chart. Obviously there were many other benefits and improvements which resulted from this program such as improved velocities, grit removal, grease removal, and control of root growth. You can safely assume that when you improve existing conditions sufficiently enough to eliminate a great percentage of potential stoppages, a corresponding over-all improvement relative to these other conditions should occur too.

In analyzing the results indicated by Table 10.1, we are not going to indicate the particular equipment or procedures used in this program. We do not want to cloud the issue by entering into a discussion as to the benefits or shortcomings of one type of equipment or procedure versus others. Our interest in this chapter is in adjusting schedules in accordance with the results achieved. How those results happen to be achieved is secondary to this discussion. Close examination of the table indicates the following:

1. At the start of the program the annual total of stoppages for all areas was 382.

2. After five years the total had dropped to 277, a reduction of approximately 27½%.

TABLE 10.1 HISTORY OF STOPPAGES DURING AN ELEVEN-YEAR PREVENTIVE MAINTENANCE PROGRAM IN SACRAMENTO COUNTY

MAP NO.	FOOTAGE ON MAP	YEAR 64	YEAR 65	YEAR 66	YEAR 67	YEAR 68	YEAR 69	YEAR 70	YEAR 71	YEAR 72	YEAR 73	YEAR 74
26	75,662	14	11	8	14	15	7	16	8	7	5	1
57	77,957	25	20	12	8	16	19	10	6	8	6	4
200	103,076	23	15	23	21	24	13	24	12	19	12	14
217	74,039	36	18	16	12	24	16	24	20	12	4	10
218	76,090	37	24	21	15	15	22	25	17	13	10	4
220	162,079	22	16	19	13	15	13	8	12	4	7	11
268	105,779	23	12	12	11	21	20	19	15	15	9	6
269	56,805	20	19	20	14	19	13	14	15	4	8	1
278	104,242	20	11	8	10	8	21	9	10	8	19	8
279	76,911	19	9	14	12	17	19	15	8	7	10	6
281	92,992	18	20	5	17	14	10	7	12	9	7	6
282	88,999	13	10	9	17	[illegible]	12	13	3	2	7	4
286	122,391	48	23	30	33	29	14	23	12	8	6	4
288	86,443	39	32	22	34	33	29	16	14	14	14	19
291	180,600	13	4	6	8	9	13	11	6	6	15	4
292	116,846	12	9	9	11	9	9	5	6	4	8	6
Yearly Totals		382	254	234	250	277	250	239	176	140	147	108

Total length of sewers on all Maps was 1,600,911 feet or 303 miles.

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3. At the completion of eleven years the total for all areas has dropped to 108. A further reduction of approximately 42% occurred during the last six year period. Total reduction for the entire eleven years was approximately 72%.

4. How do we account for the significant improvement which occurred during the last six years? Schedule adjustments and changes in procedures were very effective. During the first five years, all areas had received practically identical maintenance procedures, although not all at the same time intervals. After five years a careful study of our procedures and the area involved was undertaken. The study revealed specific problems located in specific areas within the total area. Schedules and procedures were adjusted to meet these specific problems and areas.

5. To illustrate, let us examine one of these specific problems. Note the reduction of percentages for the last six years in these particular areas:

Map #217, stoppages reduced from 24 to 10,	58%
Map #286, stoppages reduced from 29 to 4,	86%
Map #288, stoppages reduced from 33 to 19,	42%

In these areas selective TV inspection was used to locate and identify the specific problem -- roots. Procedures effective in dealing with root problems were indicated, hence the improvement.

When studying and analyzing the over-all results indicated on Table 10.1, there are two important factors that should be considered. Number one, all areas have aged ten years. Number two, the increase in physical size of each area served and the population growth or the increased loading on the system would average about 50% for all the areas involved. Another possible approach to comparing stoppages on an annual basis is to convert total stoppages to a per mile basis or so many stoppages per mile.

Finally, there is one important point that should be stressed relative to what the table reveals. It clearly indicates that what we have been discussing in this chapter is possible. A planned maintenance schedule can achieve its objective -- continuing improvement of existing conditions within the areas where most needed.

QUESTIONS

10.3C How would you prepare an effective schedule for maintaining a wastewater collection system?

10.3D How does a person gain knowledge of or become familiar with a collection system?

10.3E What time factors should be considered when developing a maintenance schedule?

10.3F Why should maintenance schedules be adjusted?

END O LESSON
2OF5 SSONS
ON
ADMINISTRATION

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 10. ADMINISTRATION

(Lesson 2 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

6. Why are good records important?
7. What kinds of information must be recorded?
8. What information would you record about a telephone call reporting a sewer overflowing at a manhole in front of City Hall?
9. What information would you give the crew sent to investigate the overflowing manhole in question 8?
10. Discuss the responsibilities of the different persons involved in collecting, filing and using records.
11. What is a preventive maintenance program?
12. What kinds of work are done by an emergency maintenance crew?
13. How would you schedule collection system maintenance crews?
14. How would you evaluate the effectiveness of your maintenance programs?

CHAPTER 10. ADMINISTRATION

(Lesson 3 of 5 Lessons)

10.4 STAFFING REQUIREMENTS

Obviously, the single most important factor which will influence the amount of staffing required is the size of the collection system to be maintained. Other important factors include age of system, condition of system, types of wastes being discharged, temperatures and population growth rates.

Several avenues could be taken to determine staffing requirements. There are formulas, based on the size of collection systems, which could be offered. Many such formulas suggest an average number of collection system workers needed for each mile of the collection system. Such formulas also indicate that this ratio of workers per mile will vary with the size of the various collection systems and the population groups being served. Generally these formulas suggest that, as population groups increase in size, the number of miles that can be covered by each individual worker will increase too. The information used, in compiling such formulas, was usually obtained through questionnaires sent to selected cities or agencies. A cross section, including small to large population groupings, and a variety of geographic and local conditions, was usually covered by such surveys. At best, such formulas would seem to indicate only suggested averages and may not recognize the fact that the agencies surveyed could have been understaffed. Aside from some value in comparing your particular situation against these averages, such formulas, we believe, would be of little use in

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x÷y+2½-½=
4½ MEN

helping you to decide on the make up of individual crews, or the number and type of crews you might require.

Another approach would be to offer suggested organizational charts for various population groupings. Here again, because of the wide variation in size of population groups and local and geographical conditions to be considered, such charts would be of little value to individuals taking this course. To cover all possible situations, charts of the largest municipality down to the smallest agency would need to be included. The larger organization would consist of hundreds of employees, including engineers, inspectors, clerks, collection system workers, permit issuers, and other personnel. The smaller organization could consist of only a manager, a secretary, and one working crew. In Chapter 11 we will show how the work crews might be organized to operate, maintain and repair a wastewater collection system.

In this chapter we have been primarily concerned with administration. Keeping to that purpose, we will confine the subject matter to considerations of an operational nature. To be specific, the make up and staffing of individual crews.

10.41 Basis of Staffing

Several important points must be considered in forming the basis for your staffing requirements.

A. Work load. Size of your collection system will have a great influence on your work load and on the amount of staff required. However, other points should be considered also.

   1. Constant work load. Any organization will have a work load that is constant to some degree based on the scope of work. Certain activites will have to be conducted on a continuing basis, simply to make the collection system functional. Your first concern should be to have adequate staffing to meet this constant work load. What is your constant work load? How do you determine the scope of your work load? Remember the sequence suggested in the introduction to this chapter.

a) Mapping. Are your maps adequate and accurate? Study the maps of your system. You must acquire a thorough understanding of and familiarity with the size, grade characteristics, locations, accessibility, and topographical conditions of your entire system. Location alone, will have a significant influence on the amount of staffing and/or equipment you may need or can use. Does your system lie mostly in streets and right of way, or is it in rear easements? If most of your system is in rear easements, your accessibility will be limited and the types of equipment available also will be limited. Production footages of crews restricted by rear easements are considerably less than for crews working in streets and unobstructed rights of way.

b) Records. Are your records adequate? Your records, if they have been accurately kept for a period of years, can be the best indication of what you can expect to be your constant work load in the future. The best records are useless, if you do not have the ability or take the time to analyze them thoroughly. Become familiar with the overall condition of your system. Where are your problem areas and how extensive are they? What are your specific problems? Roots? Grease accumulation? Poor grade? Insufficient capacity? Infiltration/inflow? Your records can and should provide the answers to all these questions.

c) Scheduling. With adequate maps and good records, you should be able to schedule maintenance intelligently with an objective in mind. Analyze your problems. A percentage of them should be of a type that can be eliminated permanently. Locate and identify these and eliminate them. A significant portion of your system may require maintenance on a continuing basis. Your schedule should be planned to accomplish this maintenance to a degree that will provide a minimum of interruptions in service or emergency situations.

d) Age and condition of collection system. How is your collection system performing now? Is it capable of operating at full capacity or is there even sufficient capacity to handle the flows? Was it properly constructed? How long ago was it constructed? Where is the ground water table? Are the soils stable? Do acid forming temperatures develop in the collection system? What are the problems? Answers to these questions and many others are critical to developing an accurate picture of staffing needs.

Now, let us be realistic. We all realize that such an orderly sequence, as suggested above, will not always be available in actual practice. However, since this is an instructional course presented in the hope of assisting you in improving your methods of operation, the above sequence is offered as a guideline to that goal of improvement. A supervisor, discovering an existing situation where such an orderly sequence has not occurred, can seek to improve the methods of staffing by application of the principles suggested in this sequence.

2. Growth potential. Today, in many areas, this is a fact of life. Many areas are experiencing rapid and substantial growth. This is a situation that many supervisors will have to cope with. Often supervisors

have difficulties justifying future staffing requirements, to the satisfaction of management, when such justification is merely based on projected growth figures. In many instances, additional staffing will be provided only after the fact - after the growth has materialized. As a supervisor you must be constantly aware of the fact that you must try to keep pace with the growth in your area. Again, the most meaningful justification you can offer management regarding your future staffing requirements may be your records. Records that will substantiate efficient use of existing staff, productivity of staff, and a positive need for future staffing are most helpful.

3. Seasonal work. Much of our work, by nature, is seasonal. Many construction and repair activities (except emergencies) will be reduced by wet or cold weather. Such crews can be reassigned to match the seasons. Reassignment of crews will be discussed later in relation to use of individual crews.

B. Objectives. Important questions to be answered in relation to staffing are "What are your objectives?" and "What level of maintenance do you plan for your system?"

Typical objectives for a wastewater collection system include:

1. Minimize number of stoppages per mile.

2. Minimize number of lift station failures.

3. Minimize number of service requests or complaints.

Once you have identified your objectives and determined how well they are being met now, you can decide how to do a better job and the staffing needed to accomplish your objectives. During budget hearings you can present graphs or charts showing how you are doing and what you could accomplish with a better trained and/or more staff.

C. Funds available. Unfortunately, this is another important factor that must be faced in acquiring the staff you need to maintain your system. Whatever objectives you may set, or how extensive a maintenance program you devise, you are surely to be restricted, to some degree, by the amount of funds available.

Fortunately the amount of funds available does not have to be the sole determining factor in the implementation of your proposed maintenance programs. Hopefully, in this course, you have learned the value of good records. As an indicator of existing conditions within your collection system, and as proof of cost effective improvement, they can justify additional funding when it is warranted.

QUESTIONS

10.4A What is the single most important factor that influences the size of your staff?

10.4B Discuss the disadvantages of using formulas or organizational charts to determine size of staff.

10.4C How can maps help determine manpower requirements?

10.4D How do records help determine manpower requirements?

10.4E Why must objectives be considered when developing staffing needs?

10.4F What factors could hinder efforts to obtain a desirable crew size?

10.42 Types of Crews

The types of crews, their individual make up and the number of each type crew required can be as varied as the size, scope of maintenance activities, program objectives, geographic locations, and management philosophies of the many collection system maintenance organizations in existence today. We do not believe it is practical to offer any kind of formula that would suggest, that for a collection system of a particular size with certain specific existing problems, you will require a given number of any particular type of maintenance crew.

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Throughout this manual, you have been given specific information relative to the type of crews that will be discussed in this chapter. Detailed instructions as to the daily functions and activities have been thoroughly covered in the other chapters.

This discussion will be confined to more general aspects of crew staffing and jobs performed by the different types of crews. Proposed is the most practical size, based on experience of others, for each particular type of crew. Also, again based on experience, suggestions will be offered as to how best to use these crews. The size of the collection system being maintained will have an influence on how each particular type of crew can be used. In large collection systems, crews tend to become more specialized and limited to performing their particular maintenance acitivity on a somewhat permanent or continuing basis. Smaller systems will find it more efficient to vary the activities of the crews at their disposal. The next section (10.5) outlines the tool and equipment requirements for these crews.

1. Emergency service request crew. Clearing stoppages is the job of an emergency crew. This is probably the basic crew in any maintenance organization. Certainly, it will be the first crew to become necessary. In smaller systems, it may be the only crew available.

   Two workers should be adequate. Depending on their work load, as an emergency crew, they can often be used for a variety of other activities. Such as,

   a) Inspection. They can be an effective inspection team to seek out and report any unusual conditions which develop within the collection system.

   b) Repair crew. They can be used as a repair crew. However, such activities should be limited to minor repairs only.

   c) Map checking. Any existing mapping system should have some monitoring in the field to assure recent additions and/or changes have been reported and included on updated maps.

   d) Inflow and infiltration. During rainy weather these crews can be useful in locating points of inflow through unauthorized points of entry into the collection system. By monitoring specific portions of the collection system where surcharging is present, they can provide valuable information relative to inflow/infiltration areas.

e) Scheduled maintenance. If your maintenance program includes rodding, either hand rodding or power rodding, this crew (being the emergency crew) could serve as the rodding crew also.

These are just a few of the various fill-in types of activities which can be performed by emergency crews. Even in the larger collection systems there are slack periods when emergencies are few and such crews can be efficiently used by assignment of fill-in work.

There is, however, one important point to consider in relation to such crews. Their primary responsibility is responding to emergency calls. Any fill-in work should, of necessity, be secondary in nature and of a type that can be quickly dropped to allow the crew to respond to the emergency at once when one develops.

2. Balling crew. Many preventive maintenance programs have one or more balling crews, depending on local conditions. The number required and the extent to which they can be used would relate directly to the size of the collection system and the conditions within that system. Many larger organizations use several full-time balling crews. Smaller organizations might require only one crew on a full or part-time basis.

Balling crews commonly consist of three workers. There could be circumstances where additional workers may be required. If the work is being carried on in a main traffic artery, additional workers may be required for traffic control. In large sewers, where a substantial amount of material is being removed, more workers may be required to aid in the removal of such material. However, it is usually not necessary to staff for such specific circumstances on a regular basis. When such conditions are encountered, additional staffing can be provided by combining available crews.

When not used on a full-time basis, balling crews can function as:

a) Repair crew. Three workers are adequate for many routine repair jobs.

b) Smoke testing. Depending on the terrain and the scope of the smoke testing program, three workers can be sufficient for limited programs.

c) Chemical crew. Again, depending on the scope of the program, three workers would be adequate in most situations.

d) Bucket machines. On a part-time basis, three-worker balling crews also can operate bucket machines.

3. Bucket machines. In many areas bucket machines are often used on a full-time basis with permanent crews assigned to such activities. Other areas will have bucket machines on a stand-by basis, to be operated only part time to deal with specific problems.

   In either situation, a three-worker crew will usually be adequate, except the same conditions would apply, as with a balling crew. Additional workers may be necessary for traffic control or when a large amount of material is being removed from the sewers.

4. High velocity cleaners. This equipment is an important part of any preventive maintenance program. Two workers are adequate to operate high velocity cleaners. However, in some areas, three workers are used.

   Most organizations who possess this equipment will operate it on a full-time basis. Rarely is this equipment parked and the crew used for other activities.

5. Power rodders. Many organizations operate this equipment full time, on a year round basis, and consider it an important part of their preventive maintenance program. This practice is considered debatable by many experienced maintenance supervisors.

The equipment is available in either truck mounted or trailer mounted models. In either case, two workers are sifficient to operate such equipment.

In organizations where the equipment is not operated full-time, it is common to find a trailer mounted unit kept available for use whenever necessary for specific conditions. Whenever this practice is followed, it is unnecessary to permanently staff operators for power rodders because they can be operated when needed by other available crews as suggested within this section.

6. Closed circuit television (CCTV). A three-worker crew is adequate. Such equipment, when available, is usually operated on a full-time basis. In most cases organizations that are large enough to purchase this rather expensive equipment will have sufficient work load to keep the CCTV equipment operating on a full-time basis.

When CCTV equipment first became available for use in the field of wastewater collection system maintenance, it was believed by many to be too complex to be operated by collection system workers. Experience has shown otherwise. CCTV equipment available today can be operated effectively by existing collection system workers with proper training. While CCTV is not particularly complex or difficult to operate, crews should have time to become thoroughly familiar with it in order to operate it with a minimum of down time. Good practice is to rotate crews, whenever possible, to assure trained workers are available whenever necessary.

7. Smoke testing crew. Rarely is there sufficient work to require a full-time crew. Smoke testing is usually undertaken to locate and identify points of inflow and illegal connections. After an area has been so tested, there is usually no cause to retest at least for a period of years.

   As previously suggested, this function can be effectively performed by other existing crews within your organization. Smoke testing is an excellent operation to be assigned during wet or cold weather. This is the time of year when the conditions you are smoke testing to find are most prevalent. It is also the time of year, due to wet weather, that crews cannot perform their normal work and are available.

   A smoke testing program of significant scope may require from three to five persons. The size of crew depends largely on the terrain of the area being tested. When using three or five-minute smoke bombs, it is often necessary to have three to five people available to provide the required coverage of the area covered by smoke bombs. Combining available crews is an excellent source of obtaining the required workers.

8. Chemical crews. Chemical crews rarely require a permanent staff. Many organizations consider chemical application as a part of the activities of existing maintenance crews.

There are a variety of chemicals being used for collection system maintenance. The methods of application are as varied as the type of chemical being used. Some require simple application of chemicals into manholes or other collection system openings. Other chemicals require plugging of downstream manholes and retention of chemical solutions within the section of line being treated for a prescribed period of time. Obviously, the number of people required will vary with the method of application being used.

Depending on the type of chemical you are using and the method of application involved, any available two or three-worker crew should be adequate to temporarily handle this assignment.

9. Repair crew. If the crew is to be operated on a full-time basis, three workers should be provided. A crew of this size will be adequate for most routine repair activities. If repairs of a larger scope must be undertaken, two or more crews can be combined depending on the situation. Repair crews, on a part-time basis, can be made available through the use of available existing crews, as previously suggested.

10. Construction crew. A fine line of definition exists in the minds of many maintenance supervisors as to what constitutes a construction crew and what makes a repair crew. A logical definition would seem to be that construction crews are engaged in new work, while repair crews deal primarily with replacement of defective portions of the collection system. Many maintenance organizations will make no such distinction. However, in many larger organizations, some construction of significant scope is often undertaken, such as, replacement of 100 feet, 200 feet, or more of damaged or defective main line. In many larger cities, also, all new building service lines for both residential or commercial properties will be constructed by collection system workers when they are to be installed in public right of ways. Such construction will require backhoes, dump trucks, and other construction equipment, and the necessary workers to operate such equipment. These crews should be three-worker crews; but they will often be combined to provide for one-day completion of work in right of ways to minimize overnight disruption of normal traffic flow.

11. Inspection crews. Inspection crews should not be confused with construction inspectors or building inspectors. Historically many organizations have used collection system workers on a full-time basis to simply inspect their system. This inspection procedure usually consisted of opening manholes and noting the condition therein. The efficiency and effectiveness of such procedures has come to be debatable as to the benefits to be realized from such a program.

    Today, many organizations will resort to such inspection procedures when they are confronted with specific problems in certain areas which they need to locate and identify. To fill this need, on a part-time basis, it is common practice to use other available two-worker crews whenever necessary.

    Properly trained inspection crews can be very valuable. They can determine the validity and nature of complaints, problems caused by industrial dischargers, and locations of trouble spots. Workers on this type of crew should know the collection system, the location of problem dischargers and something about their discharge schedules or practices.

12. Flushing crews. In recent years the practice of flushing has rapidly diminished. Experience has taught most supervisors that this practice is of little value in cleaning a collection system in most cases. The most to be accomplished by flushing is a temporary increase in velocities. Such increased velocities merely spread out accumulated deposits within the system over a larger area. The only effective method of cleaning a sewer is to remove deposits. Flushing will not remove deposits.

If you feel you must flush a sewer, two methods have been commonly used. Water can be introduced into your system from the nearest available fire hydrant by means of a fire hose. (If this method is used, local regulatory agencies will often require an air-gap or back-flow protection between the domestic water supply and the wastewater collection system.) Another simple method is to transport water to the manhole by means of a water truck. In either case, a two-worker crew would be sufficient.

QUESTIONS

10.4G Why do maintenance crews tend to become more specialized in larger collection systems than in smaller collection systems?

10.4H What is the basic crew in most maintenance organizations?

10.4I How many workers are usually on an emergency crew?

10.4J List some of the other activities that might be done by an emergency crew when there are not any emergencies?

10.4K What factors help determine the number of workers on a balling crew and the extent to which they are used?

10.4L What other jobs are often done by balling crews?

10.4M How often are high velocity cleaners commonly used?

10.4N Is closed circuit television equipment too complex to be operated by most collection system workers?

10.4O Why should crews be rotated from job to job?

10.4P What is the purpose of a smoke testing crew?

10.4Q What is the difference between a repair crew and a construction crew?

10.43 Safety

Today's stringent safety requirements established by OSHA have had a direct influence on the amount of staffing required to perform almost all of our various maintenance activities.

A. Influence on staffing. Increasing concern and enforcement exist today by local, state, and federal safety agencies to insure that collection system workers obey required safety regulations. Less than full compliance with these safety regulations is unacceptable. Supervisors must recognize and accept this responsibility. You must have an established and regularly scheduled safety program.

1. Traffic control. Requirements for providing adequate traffic control to safeguard the motoring public, as well as your own workers, can have considerable influence on the amount of staffing required (see Chapter 4, Section 4.11, Traffic Safety).

TRAFFIC SAFETY
HI! PLEASE TURN BACK AND REVIEW SECTION 4.11 ON PAGE 4-2

2. Shoring. Strict compliance to existing shoring requirements, which must be met at all times, also can require additional staffing on certain excavation projects (see Chapter 6, Section 6.2, Shoring).

3. Confined spaces. The latest safety requirements relative to people working in confined spaces, including manholes, would appear to make the two-worker crew obsolete. Such requirements indicate two workers are needed on the ground surface (besides the worker in the manhole) in order to be capable of physically removing the worker in the manhole when and if an emergency arises (see Chapter 9, Section 9.5, Manholes and Other Confined Spaces).

Throughout this section, we have made constant reference to two-worker crews. How can you operate two-worker crews and conform to existing safety regulations? In most cases, it is possible. All of our maintenance procedures are designed to minimize the need for a worker to enter a manhole. This is especially true of two-worker crews and the work to which they are assigned. On those occasions when it becomes necessary for one of the two workers to enter a manhole, the foreman is called to act as the third worker. This procedure can work very well. It is certainly a more acceptable alternative than to require all crews to consist of three workers.

10.44 Training, Information and Certification

In this section we have suggested that it is often possible and feasible to use one maintenance crew for a variety of activities. This is not to suggest that maintenance collection system activities are so simple that they can be performed effectively by untrained workers.

A. Importance of training. A prime responsibility of every supervisor is to see that all workers are properly trained to recognize all hazards and disciplined to effectively accomplish the tasks they are assigned. Supervisors must motivate workers to use safe procedures.

1. On the job. Unfortunately, to this point in time, there has been very little offered in the field of formal courses to assist in training collection system workers. Much of the training offered or given, has been some type of "on-the-job training" usually given by available and experienced collection system workers.

   This type of training, of course, is important and it has been effective to a degree. Proof of its effectiveness is indicated by the fact that collection systems have continued to function and in many areas improved their efficency through the efforts of such training.

   One possible limitation is evident in this type of training. Being "in house", it could be too narrow in scope. This training tends to be limited to local conditions, philosophies, and experience unless the instructor makes special efforts to broaden the scope.

2. Trade magazines and papers. Another valuable source of training has been available through articles printed in local or national trade magazines. Local or area wastewater associations present periodic workshops where experienced collection system workers offer papers that are of value in training less experienced people in the field of collection system operation and maintenance. Such workshops make information available to smaller organizations in remote areas who would otherwise not have the benefit of such broad experience.

3. Formal training. Recently through the efforts of local and state water pollution control associations, the Water Pollution Control Federation, and the U.S. Environmental Protection Agency, attempts are being made to make formal training available to all collection system workers. Such training also is being made available to others not now in the collection system field, but who would like to prepare for jobs within the field. This particular training course is a result of such efforts.

4. Training available. A supervisor should participate in whatever training is available now. As suggested in this section, it is possible to train crews to perform effectively even with the absence of formal training aids. It is inefficient supervision to assign crews to perform work without some form of adequate training. The lack of formal courses or training material does not make adequate training impossible, it only makes it more difficult.

   Effective training techniques include informal meetings using drawings on available material, suppliers, knowledge of crew, and invited guests to talk over how to do specific jobs. Suppliers are often available to train new workers and retrain existing workers on use of equipment.

5. Training for supervisors. Every manager and supervisor must develop a personal continuing education program. Managers must keep up to date with technical advances in their field and also develop management skills.

B. Information. Along with training, your collection system workers also should be kept informed. The information we refer to is that information usually available to their supervisor.

1. Results achieved. A good supervisor will know if the maintenance program is producing the desired results. The supervisor will be proud to make management aware of success. But how about the collection system workers? Supervisors should be equally concerned with making them aware of the results achieved. Recognize a good job or achievement promptly. Effective recognition includes a pat on the back, a pay raise, and/or more responsibility. The worker and fellow workers should know that a good job is appreciated.

2. Annual meeting. Collection system workers who have spent a year balling, rodding, operating a high velocity cleaner, and TV equipment, have a right to know what their year's efforts have produced. A wise supervisor will make it a practice to hold an annual meeting with the workers to inform them of their accomplishments. This does not have to be a "pat on the back" meeting. The crews will appreciate the consideration shown in appraising them of the part their particular function has played in the objectives of the total maintenance program. Without being told specifically, they will not become aware of their importance to the organization. Such awareness will result in increased effort on their part to improve their performance from year to year.

C. How to keep up to date. Everyone has trouble keeping up to date with new ideas, techniques, instruments and equipment. By taking advantage of training opportunities and by reading available information, you can become well informed and knowledgeable about new information in your field.

D. Certification. Passing a certification examination indicates (certifies) that you possess a specified level of competence. A good approach to gain training, obtain information and keep up to date is to prepare for certification exams. Passing the exams shows that you have learned the material and are capable of applying your knowledge to your job.

QUESTIONS

10.4R How have safety requirements influenced the amount of staffing required to perform maintenance activities?

10.4S What has been the impact of safety requirements on the two-worker crew?

10.4T Why should maintenance crew members be properly trained?

10.4U How can maintenance crew members be trained?

10.4V What kind of information should be given to maintenance crews?

10.4W What is the purpose of an annual meeting?

10.45 Selection of Workers

In addition to determining the type and number of crews and the knowledge and skills needed by crew members, supervisors also have to hire, train, evaluate, promote, discipline and compensate workers. Hiring is especially important because once you hire a worker, your agency has made a considerable investment in this worker in terms of wages, training and future potential. As a supervisor you should not allow the personnel department to make decisions for you because your relationship with your workers will be weakened. Workers must know that their supervisor has the real power to influence their jobs.

How can you select the best applicant for a job? First, decide what a worker needs to know and be able to do to perform the job. Try to match each applicant's ability with the demands of the job. Consider the applicant's experience, education, personality, and potential. Remember that your workers are continuously in contact with the public and good impressions are as important as being able to do a job safely and properly.

When you are ready to hire a new worker, usually you make your decision at an employment selection interview. The purpose of the interview is to allow the supervisor to learn something about the applicants and to select the best qualified applicant. Prepare for the interview in advance. Review the background information of each applicant. Plan the interview, including a list of questions to ask each applicant. When collecting background information and preparing a list of questions, you must be sensitive to the civil rights of the applicants and the affirmative action policies of your agency. A list of acceptable and unacceptable pre-employment questions are outlined in Table 10.2 to serve as a guide.

Try to conduct the interview in a quiet place where there will be a minimum of distractions such as phones ringing, noisy typewriters and other persons talking or overhearing the interview. Start the interview by placing the applicant at ease. A discussion of something which does not refer to an applicant's ability or eligibility for the job will be relaxing. Opening topics could include results of ball games, weather, traffic or parking problems.

Explain to the applicant the details of the job, working conditions, wages, vacations, potential for advancement, and other important factors. Hopefully by now the applicant has relaxed. Give the applicant a chance to ask questions about the job.

Now the supervisor is ready to start asking the applicant questions regarding ability to do the job. These questions should be pertinent and appropriate to the work situation. Try to determine why the applicant applied for the job and the extent to which the applicant feels qualified.

TABLE 10.2. ACCEPTABLE AND UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES[a]

ACCEPTABLE PRE-EMPLOYMENT INQUIRIES	SUBJECT	UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES
"Have you ever worked for this agency under a different name?"	NAME	Former name of applicant whose name has been changed by court order or otherwise.
Applicant's place of residence. How long applicant has been resident of this State or city.	ADDRESS OR DURATION OF RESIDENCE	
"Can you, after employment submit a birth certificate or other proof of U. S. citizenship or age?"	BIRTHPLACE	Birthplace of applicant. Birthplace of applicant's parents, spouse or other relatives. Requirement that applicant submit a birth certificate, naturalization or baptismal record.
"If hired, can you furnish proof of age?" /or/ Statement that hire is subject to verification that applicant's age meets legal requirements.	AGE	Questions which tend to identify applicants 40 to 64 years of age.

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[a] Courtesy of Marion B. McCamey, Affirmative Action Officer, California State University, Sacramento, California.

TABLE 10.2 (Continued)

ACCEPTABLE PRE-EMPLOYMENT INQUIRIES	SUBJECT	UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES
Statement by employer of regular days, hours or shift to be worked.	RELIGIOUS	Applicant's religious denomination or affiliation, church, parish, pastor, or religious holidays observed. "Do you attend religious services /or/ a house of worship?" Applicant may not be told, "This is a Catholic/Protestant/Jewish/atheist organization."
	RACE OR COLOR	Complexion, color of skin, or other questions directly or indirectly indicating race or color.
Statement that photograph may be required after employment.	PHOTOGRAPH	Requirement that applicant affix a photograph to his/her application form. Request applicant, at his/her option, to submit photograph. Requirement of photograph after interview but before hiring.
Statement by employer that if hired applicant may be required to submit proof of citizenship.	CITIZENSHIP	"Are you a United States citizen?" Whether applicant or applicant's parents or spouse are naturalized or native-born U.S. citizens.

TABLE 10.2 (Continued)

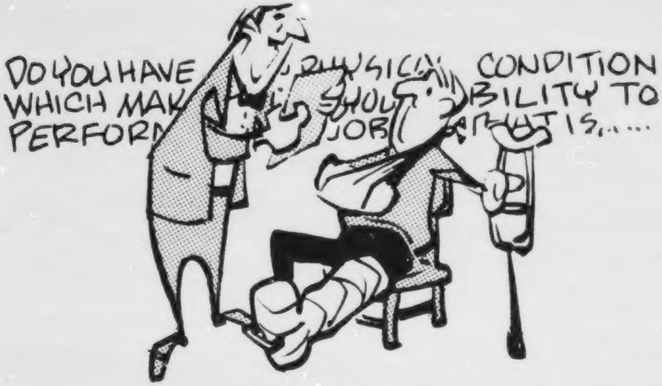
ACCEPTABLE PRE-EMPLOYMENT INQUIRIES	SUBJECT	UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES
	CITIZENSHIP (Con'd.)	Date when applicant or parents or spouse acquired U. S. Citizenship.
		Requirement that applicant produce naturalization papers or first papers.
		Whether applicant's parents or spouse are citizens of the U. S.
Language applicant reads, speaks, or writes fluently.	NATIONAL ORIGIN OR ANCESTRY	Applicant's nationality, lineage, ancestry, national origin, descent or parentage.
		Date of arrival in United States or port of entry; how long a resident.
		Nationality of applicant's parents or spouse; maiden name of applicant's wife or mother.
		Language commonly used by applicant. "What is your mother tongue?"
		How applicant acquired to read, write or speak a foreign language.
Applicant's acedamic, vocational, or professional education; schools attended.	EDUCATION	Date last attended high school.

TABLE 10.2 (Continued)

ACCEPTABLE PRE-EMPLOYMENT INQUIRIES	SUBJECT	UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES
Applicant's work experience Applicant's military experience in armed forces of United States, in a State militia (U.S.), or in a particular branch of the U. S. armed forces.	EXPERIENCE	Applicant's military experience (general). Type of military discharge.
	CHARACTER	"Have you ever been arrested?"
Names of applicant's relatives already employed by the agency.	RELATIVES	Marital status or number of dependents. Name or address of relative, spouse or children of adult applicant. "With whom do you reside?" "Do you live with your parents?"
Organizations, clubs, professional societies, or other associations of which applicant is a member, excluding any names the character of which indicate the race, religious creed, color, national origin, or ancestry of its members.	ORGANIZATIONS	"List all organizations, clubs, societies, and lodges to which you belong."

TABLE 10.2 (Continued)

ACCEPTABLE PRE-EMPLOYMENT INQUIRIES	SUBJECT	UNACCEPTABLE PRE-EMPLOYMENT INQUIRIES
"By whom were you referred for a position here?"	REFERENCES	Requirement of submission of a religious reference.
"Do you have any physical condition which may limit your ability to perform the job applied for?" Statement by employer that offer may be made contingent on passing a physical examination.	PHYSICAL	"Do you have any physical disabilities?" Questions on general medical condition. Inquiries as to receipt of Workers' Compensation.
Notice to applicant that any misstatements or omissions of material facts in his/her application may be cause for dismissal.	MISCELLANEOUS	Any inquiry that is not job-related or necessary for determining an applicant's eligibility for employment.


DO YOU HAVE ... PHYSICAL CONDITION
WHICH MAK... SHOU... BILITY TO
PERFOR... JOB ... WHAT IS......

Evaluation of applicants after an interview is often difficult. Most people are favorably impressed by the "good talker". A look at your existing workers can remind you that the best talker may not be the most productive worker. Also beware of the overqualified applicant. Naturally you want the best applicant, but a worker that is overqualified may become disappointed with the job and hurt the moral of the other workers.

When the interview is over, inform the applicant of your decision. The applicant will be hired, will not be hired, or will be notified of your decision after the others are interviewed and within a specified number of days. Be honest with the applicant. Employment interviews are an opportunity to build good public relations for your agency today and in the future. If an applicant is not qualified for the job now available, but appears qualified for another job, encourage the applicant to investigate the other job.

10.46 Labor Relations

Some supervisors are up to their ears in labor relations and unions and others have never met a union representative or a shop steward. If your workers have not been organized by a union, perhaps by reading this section you can understand why workers have joined unions and how you can help your workers obtain the benefits others have gained with the help of a union. Collection system workers have joined unions in hopes of achieving higher wages, greater benefits, and other economic objectives, as well as improved working conditions. From the viewpoint of the collection system worker, this section will help you and your shop steward understand how to work with your supervisor and also understand the supervisor's responsibilities. If your agency is not under a union contract, this section can help workers and supervisors understand how conflicts and problems can be solved.

Whether your workers belong to a union now or may join one in the future, a good labor-management relationship is crucial to keeping your agency functioning properly. Managers, supervisors, crew leaders and workers all have to want to work together to develop a good relationship. The supervisor is the critical link in the relationship and is management's daily representative with the workers.

During labor negotiations, management should be in constant consultation with the supervisors. Many labor or contract demands regarding working conditions originate from the supervisor's daily dealings with the workers. An effective supervisor can minimize unreasonable demands. Also any demands that are agreed upon must be implemented and carried out by a supervisor. Although a supervisor does not participate directly in labor negotiations, the supervisor can help both sides reach an acceptable agreement.

Once a labor contract has been agreed upon by labor and management, the supervisor must manage the organization within the framework of the contract. Do not attempt to ignore or "get around" the contract, even if you disagree with some of the clauses or feel they hinder you from achieving your objectives. If you do not understand certain contract provisions or the spirit of the agreement, request management to explain this portion of the contract to you BEFORE you apply these clauses to your daily working situation.

Labor agreements do not change the supervisor's delegated authority or responsibility. Workers must carry out the supervisor's orders and get the job done properly, safely and within a reasonable amount of time. As a supervisor you must learn to do your job within the framework of the labor contract and to overcome any union-imposed obstacles.

CONTRACT PROVISION
PORTION OF CONTRACT
RESPONSIBILITY
FRAMEWORK OF
TO MAKE DECISION
YOUR DECISION
SPIRIT OF THE AGREEMENT
PLUS DELEGATED AUTHORITY OR
GET JOB DONE WITHIN THE
CONTRACT - RIGHT OR DUTY
RIGHT TO PROTECT OR CHALLENGE
RESPONSIBILITY

As a supervisor you must always realize that as a member of management you have the right and even the duty to make decisions. However, a contract gives a union the right to protest or challenge your decision. When a worker requires discipline, disciplinary action is a management responsibility and a right. The supervisor has a duty to take action whenever workers do not comply with contract provisions.

Most of a supervisor's union contacts are with a shop steward. The shop steward is elected by the union workers and is their official representative to management and the local union. The steward is in a difficult position because the steward is a worker that is expected to do a full-time job like the other workers, yet also represent the workers. The steward must create an effective link between the supervisor and workers.

Handling grievances can be a very time consuming job for both the supervisor and the steward. Grievances can develop over disciplinary action, distribution of overtime, transfers, promotions, demotions and interpretation of labor contracts. The steward must communicate complaints and grievances from workers to the supervisor. The supervisor and the steward must work together to settle complaints and adjust grievances. Union contracts usually spell out in great detail the steps and procedures the steward and the supervisor must follow to settle differences. When a shop steward and supervisor can effectively work together, the steward can keep the supervisor on the ball and force the supervisor to be an effective manager.

Successful handling of complaints and adjusting grievances requires cooperation by both the shop steward and the supervisor. Both have to use judgement, tact and patience and somehow do their daily work also. The better they can work together, the fewer grievances will develop and become serious, and the less time will be consumed settling problems.

The supervisor usually is presented a grievance by the shop steward. The worker with the problem should be present too. During the presentation and discussion, the supervisor should listen carefully and sympathetically to the steward. The supervisor may discuss the problem with the worker either with or without the shop steward. Both the steward and the supervisor should try to identify the facts and the cause of the problem.

If at all possible, grievances should be settled quickly and to the satisfaction of everyone. Try to prevent little grievances from becoming big ones and going on up the line to top management. To try to solve grievances at an early stage, the supervisor should be available to the shop steward and worker with a problem. Both the supervisor and shop steward must listen sympathetically to each others' viewpoints and avoid becoming angry. They should obtain accurate facts, review the labor contract for pertinent clauses, and try to settle the grievance as quickly and justly as possible. The consequences of any solution to a grievance must be considered and solutions must be consistent and fair to the other workers. The solution or settlement should be clear and under-

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standable by everyone involved. Written records must be maintained and properly filed that document the entire grievance procedure from initial presentation to final solution and settlement. The supervisor and the shop steward should review the final report together to be sure the intent of the solution is understood and properly documented.

QUESTIONS

10.4X How can you select the best applicant for a job?

10.4Y What do you think is the secret to conducting a good employment selection interview?

10.4Z What should be the relationship between the supervisor and the shop steward?

10.47 Additional Reading

1. Namour, Elie, Manpower Requirements for Wastewater Collection Systems in Cities and Towns up to 150,000 in Population, Washington, D.C., Manpower Development Staff, Office of Water Program Operations, U. S. Environmental Protection Agency, June 1973.
2. Namour, Elie, Manpower Requirements for Wastewater Collection Systems in Cities of 150,000 to 500,000 in Population, Washington, D.C., Manpower Development Staff, Office of Water Program Operations, U. S. Environmental Protection Agency, June 1973.

3. White, Katie, A., Recruitment, Retention, and Utilization of Personnel in Wastewater Collection Systems in Cities and Towns with Populations up to 150,000, Washington, D.C., Municipal Permits and Operations Division, Office of Water Program Operations, U. S. Environmental Protection Agency, July 1974.

END OF LESSON 3 OF 5 LESSONS ON ADMINISTRATION

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 10. ADMINISTRATION

(Lesson 3 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

15. How would you determine the types of crews needed to operate, maintain and repair a wastewater collection system?

16. How would you determine the number and sizes of crews for a wastewater collection system?

17. What do you think are important objectives for the supervisor and the crews for a wastewater collection system?

18. How often do you think crews should be rotated from job to job? Why?

19. Why must crews receive safety training?

20. How would you develop a training program?

21. How would you attempt to hire a new worker?

22. What is the job of the supervisor in labor relations?

CHAPTER 10. ADMINISTRATION

(Lesson 4 of 5 Lessons)

10.5 TOOL AND EQUIPMENT REQUIREMENTS

Many of the tools and equipment we will be discussing have been thoroughly reviewed where they are used in other chapters in this manual. Detailed instructions have been given as to how each can and should be used. The advantages and limitations of each, relative to their abilities to cope with specific problems, have been explained. In this chapter our comments will be limited to points of interest to supervisors.

10.51 Basis for Requirements

As with staffing, the basis for tool and equipment requirements will depend largely on such things as size of collection system, work load, and objectives. Other important factors include age of system, condition and type and number of problem areas.

A. Equipment tailored to fit your program. This is an important factor to consider. Quite often the opposite is true. Programs are designed to fit the equipment available. In many cases this does not come about by choice, it merely developes from circumstances. What circumstances? How does this situation develop? Quite simply. Prior supervisors or management acquire the necessary tools and equipment needed to carry out their desired programs. However, as time passes, subsequent supervisors may find this available equipment not suited to their current plans or programs. This can be due to a variety of reasons, such as:

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1. *Changing conditions within the collection system,*
2. Development of more modern and specialized equipment, or
3. More intelligent approach and appraisal of existing problems and needs by current supervisors and planning for a more effective program.

How this situation came about is really not important. The important point to consider is to be able to recognize this situation when it does occur and, even more important, to have the knowledge and the courage to document and justify your request for adequate tools and equipment which you feel you will need to implement your programs and objectives.

1. Multi-purpose equipment. One of the most frequently asked and difficult questions to be answered by supervisors in the field of collection system maintenance is what kind, type, and size of equipment should be purchased? Smaller organizations who cannot afford or justify the need of the varied specialized equipment that is available find this problem especially difficult. With $10,000 or $20,000 in available funds, what one piece of equipment will be the most versatile and efficient in coping with the variety of problems faced in the collection system? We will not attempt to answer that question. Instead, we offer this analogy.

   You are a homesteader with a small plot of land. To make the land productive you will have to hoe some weeds and dig some shallow, narrow ditches. What you need is a hoe and a shovel. But you can only afford one tool. The hoe would be best for cutting the weeds, a shovel the best for digging the ditches. If necessary, you could cut the weeds with the shovel, or dig the shallow ditches with a hoe. Which tool do you buy? If weeds are the predominant problem, you would buy the hoe. If ditches are the major work load, the shovel. The homesteader will know his particular need and make his choice accordingly.

As a maintenance supervisor, you could be facing a decision very similar to the homesteader's choice. However, your decision will be more complex and not so simple to solve. We have learned in this course that certain equipment will do an excellent job of removing roots, another will be most efficient in removing grease accumulation, and still another most effective in removing grit and solid material that has settled out within the collection system. Some equipment has been suggested as efficient, to a degree, in dealing with all these problems (see Chapter 5, Section 5.14, Selection of Solution to Problem, Tables 5.1 and 5.2).

As a supervisor, you should have the knowledge and the experience to recognize what is your predominant maintenance problem and which equipment would do the best over-all job in your collection system.

2. Specialized equipment. Much of the equipment which is available today for collection system maintenance is specialized. Many of the manufacturers will claim their equipment is capable of dealing with a variety of maintenance problems. And, to a degree, they are correct. But, it also is true that most modern collection system maintenance equipment has one particular function that it performs most effectively.

   In making the decision to acquire specialized equipment, one should proceed with much caution, consideration, and thorough analysis of your collection system. Do you have a specific problem prevalent within your system and of sufficient proportions to justify acquisition of such specialized equipment? Throughout this country in many maintenance yards you will find such equipment parked. It stands idle much of the time because its need and/or efficiency was overrated.

B. Efficient use. Modern maintenance equipment is expensive. The workers needed to operate it are expensive too and in most cases must be better trained. The supervisor should be constantly concerned that the equipment is being operated efficiently. As previously stated, most equipment has one function which it does best. The supervisor should be certain that the equipment is being used in those areas where it is most needed. The shotgun approach of "going through a system at set intervals with one piece of equipment" is wasteful and unnecessary. Unfortunately it is a common practice.

10.52 Lease, Purchase, or Contract

Your organization does not need to have the funds to purchase the equipment required to implement your maintenance programs. All types of construction and maintenance equipment are available through long or short term leasing, as well as by outright purchase. This has made available, to the smaller agencies in particular, many items of equipment which they could not justify sufficient need for in the past. Larger organizations also have an alternative to outright purchase of expensive equipment which requires an initial investment of a significant amount.

A. Advantages of leasing. There are advantages to be realized through leasing to both the large organizations and smaller agencies.

1. Large organizations. Naturally the first benefit to be realized is that expensive equipment can be available without an initial capital expenditure of considerable amount. But there are other important benefits to be considered. Many large organizations have purchased expensive equipment such as closed circuit television or high velocity cleaners. Much to their disappointment, in some cases after a short time of operation, they found similar equipment was available which was superior to that which they had purchased. Because of the initial investment, they have little choice but to keep and use their original equipment over a period of years necessary to amortize their original investment.

Another advantage is that most leasing agreements can be negotiated on a one to three-year basis for this type of equipment. This assures you that you will not be faced with operating equipment that has become obsolete in some respects. When new developments and improvements become available, they can be easily acquired through new leasing agreements.

2. Small agencies. Perhaps the greatest benefits are to be realized through leasing by the smaller agencies. Often their anticipated need or work load would not even allow consideration of purchasing needed equipment outright. With leasing, all types of equipment may be within their financial capabilities for short time periods to do specific jobs. If a need can be justified, leasing for a limited time period should be an easier approach to sell top management than buying equipment for part-time use.

Prior to leasing, an alternative was to employ outside contractors who provided both the staff and the equipment needed to do the job. Such contracts often were expensive.

Many leasing agencies will provide a break-in time and training period to train your own workers as part of the leasing agreement. This is usually a less expensive method than contracting for both staff and equipment.

3. Common advantages. Leasing offers advantages common to any size agencies. It makes any specialized equipment available at reasonable cost to complete any one-time or seasonal programs you may want to undertake. Some leasing agreements allow the municipality or agency to apply equipment leasing costs toward the purchase of the equipment if the agency determines that the equipment leased best suits their present and future needs. Some state municipal leagues have technical assistance offices that have conducted studies on the costs and benefits of leasing and purchasing.

Often leased equipment can be obtained quicker than purchased equipment. When leased equipment breaks down, usually it is quickly replaced because the agency doesn't have to pay for equipment that doesn't work.

4. Limitation. Total cost may be more in the long run than purchase, but costs are spread out over the years while the equipment is being used.

B. Advantages of purchasing. Regardless of size there are advantages to any organization in outright purchase of some types of equipment. In general, such purchase should be limited to the more standard equipment that is used frequently, with a long life span and representing capital investment within the scope of the available budget.

Limitations:

1. Large initial capital investment.
2. Equipment must be kept and used 5 to 8 years in order to build up a replacement fund.
3. Difficult to obtain newer models that are capable of doing a better job until old equipment wears out.
4. Equipment may require specially trained workers to provide proper maintenance.

C. Advantages of contracting. Sometimes your agency may not have sufficient qualifed or qualifiable staff available to do a highly specialized job. Under these conditions, a contract with a firm specializing in solving a particular problem may be the best approach.

Limitation:

May be most expensive method, but satisfactory for a small job that can be done in a short time.

QUESTIONS

10.5A How can tool and equipment requirements be determined?

10.5B Is most of the equipment available for collection system maintenance specialized or is it capable of dealing with a variety of problems?

10.5C Why is the shotgun approach of "going through a system at set intervals with one piece of equipment" not recommended?

10.5D How can an agency implement a preventive maintenance program when it does not have enough money to purchase the necessary equipment?

10.5E What are some advantages of leasing equipment?

10.5F What are some advantages of purchasing equipment?

10.5G What are some advantages of contracting for work?

10.53 Mobile Equipment, How Equipped

Many of the items of equipment to be discussed may or may not have been mentioned elsewhere within this manual. This section outlines the equipment and tools a supervisor might wish to consider essential for efficient operation of major pieces of equipment. The size of equipment depends on the size and type of job, the number of units or pieces of equipment required, size of sewer, and nature of problem. To select equipment, look at the maintenance program. Plan the program for an entire year and obtain the equipment needed to do the jobs in the program.

A. Basic automotive equipment.

1. Supervisors. Supervisors should be provided with a sedan for transportation. In most areas it will be the most practical and economical transportation. Some levels of supervision, such as foremen, may be better served by a pickup truck. This type of truck provides space for carrying safety equipment, such as barricades, and also provides space for foremen to carry supplies to crews in the field. In both cases, two-way radio equipment or paging devices will add to the efficiency of the operation.

All vehicles should be equipped with a fire extinguisher and a first aid kit of adequate size. **All workers must** have their personal safety equipment with them at all times. Vehicles must contain vehicle and personal accident forms.

2. Emergency crews. At least a 3/4-ton truck should be provided emergency crews that clear stoppages. The size of the truck could be larger if this crew is to serve as a repair truck when not on emergency calls. If two-way radios are limited in number, the emergency crew should receive high priority for obvious reasons. An enclosed utility type body also is desirable. Adequate, clean, dry storage area for all necessary maps of the system is a must for this vehicle.

3. Maintenance crews. A variety of crews can be referred to as maintenance crews. Some, using specialized automotive equipment, will be discussed in subparagraph B, Specialized Equipment. Equipment needs of other crews using more common equipment might include:

   a) Balling crew. A one-ton flat bed, equipped with tool boxes, is commonly used. This truck should carry a hand operated portable reel with light cable for balling smaller lines in rear easements. Also it should be equipped with a power winch, powered by an auxilliary engine, or by a pto[1] assembly to the truck motor, for balling larger lines in the street. A one-ton trailer for hauling grit removed from the system should accompany each truck. Two-way radio equipment or paging devices are not ordinarily required for such vehicles because their daily assignment will usually be confined to a reasonably small area and they can easily be contacted if necessary.

b) Rodding trucks. (Other than truck mounted power rodders.) If your rod crews consist of hand rodding, or tow trailer mounted power rodding machines, a 3/4 or 1-ton truck should be adequate. A utility type body is desirable. Depending on the number of such crews available, it may be wise to equip at least one with a two-way radio or paging device to make it available for emergencies.

4. Construction crews. The basic truck for most such crews should be at least a 1½-ton flat bed. Load capacity should be sufficient to carry the heavy materials these crews ordinarily use. Such materials can consist of collection system pipe and fittings, manhole grade rings, manhole barrel sections, small amounts of paving material, aggregate and cement, road rock, and sand. A bigger truck will be required for larger jobs. These crews usually work in the same location all day so two-way radio equipment or a paging device is not required.

5. Service line and manhole repair crews. A 1-ton truck should be adequate in most areas. Size could depend on the particular use these trucks are

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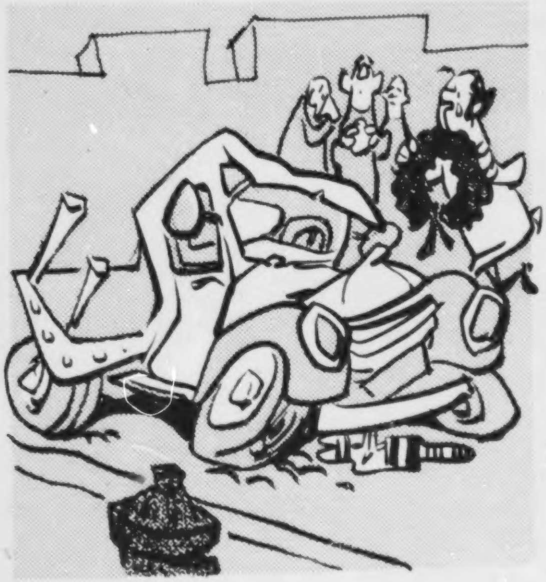
[1] Pto. Power Take Off.

assigned to and by the individual organization. If you have only one repair crew to handle any size repair project, you may want to obtain a larger truck like the one described above for construction crews. Also, depending on the number of such trucks available, you may want to equip one such truck with a two-way radio or a paging device for emergency use when needed.

B. Specialized Equipment.

1. High velocity cleaners. This equipment is available in both truck mounted and trailer units. Truck mounted units are most commonly used. Special care should be exercised in selection of the truck to carry this unit. Because of the considerable weight of the water carried in their tanks, it is possible to specify a truck that is of inadequate capacity, or marginal capacity, for the loads involved. Frequently, such under or insufficient capacity will not become apparent until the truck has been in use for a period of time. With use, brake problems may develop, springs weaken, road handling becomes less efficient, and even a loss of engine power could become evident. Unfortunately, by the time these conditions materialize, it is often too late to remedy. The truck is yours and guarantees have expired. Again, specify a truck that is oversized, never one that is marginal in capacity.



2. Television. A variety of units are available. Self-contained vans, large trailer units, and small compact trailer

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units. It is impractical to suggest a particular type of unit best suited for any organization. All have advantages. The smaller units, naturally, are practical where their use may be limited. All trailer units have the advantage of making the towing vehicle available for other uses when the television trailer is not in use. Truck mounted units provide easier handling and operation in congested traffic areas.

3. Rodding machines. This equipment also is available in truck mounted or trailer mounted units. When such equipment is used on a full-time basis, the truck mounted unit is preferable. Trailer units are advantageous when they are to be used less than full time. These units can be towed by a 3/4-ton truck or larger, depending upon the size of the rodding machine unit.

4. Bucket machines. These units are trailer mounted and are used in pairs. They are so equipped that they can be towed in tandem by one vehicle. Vehicles of at least 3/4-ton capacity should be used when towing two such units. Where large lines are being cleaned and large amounts of material being removed, a dump truck may be required. Attachments to the bucket machines are available which will allow for direct deposit of the material being removed into the trucks. This makes unnecessary the dumping of the material onto street surfaces and subsequent loading of such material into trucks by hand shoveling.

5. Pumps, trailer mounted. Some equipment of this type will be advantageous to most maintenance organizations. At least a 4-inch diameter discharge should be the minimum size for the pump. Larger sizes of 6, 8, 10 inch or larger discharges could be used by bigger organizations.

   These units are usually trailer mounted with their own pump power source and are portable. Trailers should be equipped to carry necessary suction and discharge hoses or pipes that are needed to set up pumps quickly in emergency situations. Such stand-by pumping units should be checked and run at regular intervals to assure that they will be in operating condition when the emergency does arise.

C. Construction and Repair Equipment.

1. Backhoes. Organizations who undertake construction or repair projects of a significant size will need backhoes. Depending on the anticipated use, backhoes can be purchased, leased, rented by the day, or hired complete with operator. Sanitary collection systems are being installed at greater depths which makes this equipment more desirable. Often, backhoes will provide the ability to complete excavation, repair, and back filling in one day. To provide mobility, a trailer of adequate size and meeting local highway regulations will be required to transport backhoes from job to job.

2. Dump trucks. A truck with a five-yard load capacity should be adequate. This truck is used as the towing vehicle for the backhoe trailer. Also it can be used to haul away excavated material when such material is unsuitable for backfill and to haul in selected backfill when required.

3. Water truck. A water truck is another piece of equipment which will be required to work in conjunction with construction crews. This truck can be used for dust control on the job site, jetting, and clean up. These trucks come in a variety of sizes and water tank capacity. Minimum size should be at least 1,000 gallon capacity.

4. Air compressors, portable. A portable air compressor is required by repair and construction crews for operation of jack hammers and tampers. Some organizations with many crews will install compressors permanently on their repair trucks. To others, where use is not so great, portable trailer-mounted units may be more practical.

Portable trailer-mounted units can be made available to a greater number of crews on a simple need basis and provide more flexibility of operation.

5. Hoists. Truck-mounted hoists, operated on 12-volt systems, are useful on repair and construction vehicles. They should be of sufficient lifting capacity to lift such items as manhole frames and covers, large size pipes, manhole grade rings, and light portable equipment.

QUESTIONS

10.5H Emergency crews should be provided with what kind of transportation?

10.5I Which crews should be equipped with two-way radios or paging devices?

10.5J Why is it important to specify a truck with adequate capacity for a high velocity cleaner?

10.5K When are truck mounted units preferable over trailer-mounted units?

10.5L Why should portable stand-by pumping units be inspected and run at regular intervals?

10.5M What major pieces of equipment are needed for construction and repairs?

10.5N Why do construction and repair crews need a portable air compressor?

10.54 Miscellaneous Equipment and Tools

This list could be almost endless. Many such tools and equipment have been mentioned or discussed elsewhere in this manual. This section attempts to comment on just a few of the more common ones and on some suggestions for their use.

A. Maintenance Equipment.

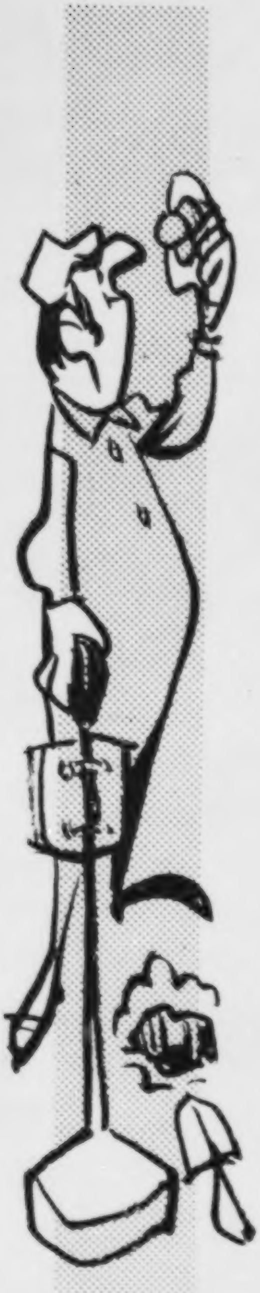
1. Sealing and testing. Equipment for air testing collection system joints for leaks and sealing such leaks whenever located is widely used today. Such equipment is usually used in conjunction with closed circuit television equipment. This equipment also is sold in conjunction with television units. One complete unit may be purchased that will provide for television inspection, air testing, and joint sealing equipment as a package mounted on a truck or trailer unit.

2. Sewer balls. Balls for cleaning collection system pipes are available in sizes from 6 inches to 48 inches in diameter. Larger sizes are available by special order. Most maintenance organizations will equip individual balling trucks with 12 inch or smaller sizes. Sizes above 12 inches become very expensive and are less frequently used. Depending on the size of the collection system, it is more practical to acquire only one each of the large size balls. These are kept in a central store or tool room and are available to whichever crew may have use for them.

3. Pumps, portable. Portable pumps, gasoline powered, with 1½ to 2½-inch discharge capacity are often required by repair and maintenance crews. These pumps are stored in a tool room and issued to crews whenever needed.

4. Generators, portable.

   a) Gasoline powered generators are needed to supply 110-volt power to crews in the field. One or more should be available in a store room to be



drawn by the crews as needed. Such generators are commonly used to provide lights for night work and 110-volt power to operate electric power tools.

b) Truck mounted generators which operate off the truck's electrical system also are available to provide 110-volt power. This equipment usually is permanently mounted to the truck. Large organizations provide selected trucks with this equipment when the need is great enough to warrant it.

5. Electronic locators. Equipment of this type will be required at some time by most maintenance and repair crews.

Different types of equipment are available. Three common types are discussed in this paragraph. The simple valve or lid locator is simple to operate, has a limited depth capability, and is most useful in locating buried manhole covers or water valves. The pipe locator is a bit more complex, but simple in operation after it has been assembled. Pipe locators are capable of greater depth location and are most effective in locating metal pipes, manhole covers, and water valves. The ferret type locator is the most complex and capable of the most accuracy. It utilizes an electronic unit which can be floated or pushed down a sewer of any type material. The locating unit is used above ground and is able to pick up a signal from the unit which is in the underground pipe and pinpoint its location and in many cases indicate the depth of the pipe. Electronic and ferret type locators do not work with metallic, cast iron or galvanized pipe.

Emergency crews will find the valve locator effective in locating buried manhole covers. This unit is relatively inexpensive and one can be furnished to emergency crews as part of the permanent equipment that is carried on their truck.

The pipe locator may be required by repair crews in locating underground utilities prior to excavation. Being more expensive, it may not be practical to supply all crews with such equipment. One available in a foreman's truck or in the tool room may be all that is required.

The ferret type is even more expensive and is limited to specific purposes. It may be of little use except to the larger maintenance organizations.

6. Plugs. Plugs are available in two common types - air and mechanical. All crews should carry at least the common smaller sizes. As with sewer balls, larger sizes are less frequently used. They should, however, be available in the storeroom to be drawn and used by any crew when needed.

   a) Air plugs. These have the advantage of being inserted and inflated from ground level which makes it unnecessary for workers to enter the manhole.

   b) Mechanical plugs. Some models also are available that can be inserted and tightened from ground level. Other models require that workers enter the manhole in order to insert and tighten the plug.

B. Construction and Repair Equipment and Tools.

1. Tapping machines. The era of hand-made taps into existing sewers hopefully has passed. This undesirable practice in earlier construction methods has been a major source of maintenance problems. Crude attempts to tap a sewer with hammers, chisels, and miner's picks often resulted in broken mains, ill-fitting taps, and taps protruding into the sewer.

These problems provide inviting areas for future root intrusion and for a person to use an excess of cement or grout in an effort to hide the crude job.

Many municipalities or agencies no longer allow tapping of their sewers by anyone other than their own workers. There are a variety of tapping machines available which are capable of providing an accurately sized, neat hole for tapping. Such machines also minimize the possibility of breaking or cracking the sewer during the tapping process. Most tapping equipment has adjustments to allow for use on a variety of pipe sizes of 6 inches and larger. The tapping machine is clamped securely in place on the sewer by attachments similar to a chain vise. A diamond core drill of the exact size to accommodate the saddle safely provides a neat hole.

2. Internal tap cutter. Internal tap cutters were developed to combat the protruding taps which resulted from former crude tapping methods. This tap cutter uses a diamond core drill to provide safe, smooth cutting. Size of the cutter is slightly under the size of the sewer in which it is being used. The cutter is pulled manually into the sewer to the location of the protruding tap to be cut off. Two inflation collars are inflated to hold it securely in place. Using air power, the core drill is turned and slowly advanced until the tap has been neatly cut off. This equipment is extremely useful when the offending tap has been located in an area where excavation for removal would be impossible or very expensive.

3. Boring equipment. In many large municipalities the cutting of major thoroughfares to allow for collection system service lines is not allowed or is impractical due to the traffic flow. In such areas, boring equipment can be effectively used. A boring pit at the edge of the right of way and a parallel excavation over the sewer in the street will eliminate cross cutting of traffic lanes. This equipment is capable of boring from 6 inch to 12-inch holes distances of over 100 feet, and is available at reasonable costs.

4. Pipe cutters. Here again, hopefully, the era of the hammer and chisel has passed. A variety of chain-type cutters are available. All are capable of neat, safe, pipe cutting. Most cutters will provide the capability of cutting existing pipe in place in the pipe trench. Manual models are available for cutting smaller sizes of pipe, ratchet models for intermediate sizes, and hydraulic models for the larger sizes.

QUESTIONS

10.5O Air testing equipment that helps detect leaks in pipes and joints often is used with what other pieces of equipment?

10.5P Where is equipment stored that is seldom used such as large size sewer balls and portable emergency pumps?

10.5Q Name three different types of electronic locators.

10.5R What are the two different kinds of plugs?

10.5S Why should hand-made taps be discouraged?

10.5T How can taps protruding into mains be removed?

10.5U How can a service line be placed under a major thoroughfare without disrupting traffic?

10.55 Safety Equipment

There is increasing concern by regulatory agencies that workers in the field of collection system maintenance be provided with safe work areas and conditions. Supervisors, regardless of enforcement by others, should be constantly concerned with the safety of their workers. A variety of safety equipment is available and will be required to meet these concerns (also see Chapter 4, Section 4.1, Traffic and Manhole Safety).

A. Atmospheric testers. A real hazard faced by all collection system workers is the atmospheres to which they are exposed. Confined spaces such as manholes and wet pits can become death traps when a sudden change in atmosphere occurs. Three main items of concern are (1) lack of oxygen, (2) an explosive condition, and (3) toxic gases (hydrogen sulfide, chlorine). The only effective equipment to detect such conditions are atmospheric testers.

   1. Single purpose testers. A variety of testers or meters are available and each one is designed to detect specific gases commonly present in collection systems such as carbon monoxide, methane, and hydrogen sulfide. See Chapter 9, Section 9.2, Gas Hazards, for a more detailed discussion of gases and testing equipment.

   2. Dual-purpose testers. A common type dual-purpose meter capable of detecting either lack of oxygen or explosive conditions may be the most effective and practical for most maintenance activities. We prefer to use dual-purpose meters. See Chapter 9, Sections 9.2, Gas Hazards, and 9.5, Manholes and Other Confined Spaces for more details.

   3. Multi-purpose testers. These testers have interchangeable parts that allow them to measure the level or concentration of several gases. For example, one instrument with interchangeable scales and calibration tubes can detect carbon dioxide, hydrogen sulfide, chlorine, sulfur dioxide and nitrogen dioxide. Another type of multi-purpose tester is capable of monitoring oxygen levels, explosive conditions (methane), and a toxic gas (hydrogen sulfide).

Consult the rules of the regulatory agencies in your area to determine the specific equipment you will need to meet their requirements and protect your workers. Regardless of such requirements, a supervisor should make available to any of the workers required to work in such confined spaces, at least the testers capable of detecting a lack of oxygen, an explosive condition and any expected toxic gases (especially hydrogen sulfide). Continuous monitoring with such testers while people are working in confined spaces should be a basic safety rule for all maintenance organizations.

B. Blowers. In conjunction with the above detection meters, there also is a need to provide blowers of ample capacity to introduce fresh air into confined spaces.

1. Portable blowers. Small, portable blowers are available and should be standard equipment on all vehicles whose crews work in confined spaces. Blowers operating on 12-volt power systems available in most vehicles are commonly used for this purpose.

2. Trailer mounted blowers. Many maintemance organizations of significant size will have available a large trailer mounted blower capable of up to 25,000 CFM air capacity. Such equipment will be needed for projects involving large diameter sewers when it is required that workers enter such sewers for inspection or repair activities.

3. Capacity of blowers. A review of the literature reveals recommended blower capacities from 4 to 20 volume changes per hour depending on conditions in the confined space. Contact your local safety officer for the requirements.

C. Shoring. Another hazard to underground collection system workers is the possibility of injury or death due to cave-ins while working in excavations. Adequate shoring must be provided for their protection. Many varieties of shoring are available. For additional information on shoring, read Chapter 3, Section 3.61, Excavations and Shoring, Chapter 6, Section 6.2, Shoring, and Chapter 9, Section 9.4, Excavations and Trench Shoring.

1. Hydraulic shoring. Hydraulic shoring is widely used, light in weight, and can be safely and quickly installed or removed from above ground.

2. Manual shoring. Manual shoring usually consists of screw jacks and wooden timbers of adequate size. Consult your area's regulatory agencies for the specific minimum size dimensions acceptable for timbers used for shoring. Installation of this type shoring is more difficult and time consuming. Workers are required to enter the excavation during the process of installation. Caution should be exercised to make sure the top screw jacks are in place first, then proceed downward to the bottom of the excavation to offer the maximum protection to workers engaged in such installation. Upon removal the process is reversed, removing the bottom jacks first and proceeding upward. Obviously, because of these disadvantages, use of this type of shoring should be limited to excavations of small size and depth.

3. Sheet shoring. Most regulatory agencies will require this type of shoring in loose or running soil conditions. Specific dimensions for the sheeting used will be required by the regulatory agency in your area.

4. Cylinder and shield shoring. Cylinder and shield shoring represent already built shoring. This type of shoring provides good protection for the worker and can save a lot of time over manual and sheet shoring methods.

5. Rental. Because of the cost of modern shoring equipment and the limited need most organizations will have for this type of equipment, it is common practice to purchase only a limited amount. This amount should be adequate to handle most routine activities. When, and if, larger projects are undertaken, the required additional shoring can be rented for the required time.

D. Traffic control. Traffic is another significant hazard faced by collection system workers. Often it is overlooked or underrated. In the interest of expediency, workers will often expose themselves to traffic flow without adequate protection. Supervisors should constantly impress upon their workers the folly of such practice. Adequate equipment for traffic control is available and supervisors should insist upon its use. Traffic control equipment includes:

1. Rotating, flashing beacons.

2. Traffic cones and delineators.

3. High level warning flags.

4. Safety vests.

All maintenance vehicles should carry and use the above traffic control equipment (also see Chapter 4, Section 4.11, Traffic Safety, and Chapter 9, Section 9.32, Traffic Control).

E. Protective clothing. Collection system workers come into contact with a variety of hazards which make protective clothing advisable.

1. Uniforms. Workers should be provided with uniforms or coveralls. Such clothing should be put on at the start of the day and removed before going home. This practice will minimize the possibility of employees, who come into contact with raw wastewater in their work, wearing contaminated clothing home and perhaps exposing their family members to these contaminants. A uniform also identifies workers with your agency which is especially helpful when access to private property is required.

2. Safety shoes. All workers should be encouraged to wear safety shoes. Some organizations provide safety shoes and make it mandatory that they be worn. Other organizations may participate in a cost-sharing program with their employees to provide for safety shoes.

3. Rubber boots. Employees who work in raw wastewater should be provided safety toe, non-skid rubber boots, with a steel shank for protection of the bottom of the feet. Many organizations provide such protection on an individual basis or need.

4. Gloves. Persons exposed to raw wastewater should protect their hands. Protective gloves eliminate or minimize infections, cuts, and infection due to cuts.

5. Eye protection. Most workers will require eye protection of some type. A program for providing safety glasses, including prescription lenses, is desirable. Safety goggles should be provided to crews exposed to flying particles. Complete face shield protection should be available to crews working with chemicals.

6. Hard hats. Hard hats should be furnished to all workers. They must be worn at all times on the job site.

7. Safety harnesses. Harnesses should be provided to all persons who are working in manholes or inside large diameter pipe. When such equipment is in use, there should be sufficient workers topside to provide for fast, safe removal of such persons should an emergency arise.

8. Regulations. Aside from these common articles of protective clothing, there may be requirements to meet specific conditions. Consult your area regulatory agency to assure you are in compliance at all times.

F. Summary. Safety awareness is extremely important. Crews must be provided with the necessary equipment. They must be given instructions on proper use and proper procedures must be followed AT ALL TIMES.

QUESTIONS

10.5V Where should the atmosphere always be tested before entering?

10.5W What are the three main items of concern when testing the atmosphere?

10.5X Why must the atmosphere be monitored continuously?

10.5Y How can fresh air be introduced into confined spaces?

10.5Z What are the different types of shoring?

10.5AA Why is traffic control often overlooked or underrated?

10.5AB Why must collection system workers wear protective clothing?

END OF LESSON 4 OF 5 LESSONS
ON
ADMINISTRATION

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 10. ADMINISTRATION

(Lesson 4 of 5 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 3.

23. How would you determine the tool and equipment requirements for a collection system?

24. Discuss the advantages and disadvantages of the different methods of obtaining equipment.

25. Why must trucks be of adequate size?

26. How can arrangements for rarely used pieces of equipment be readily available to all crews when needed?

27. What kind of safety equipment is needed for each type of maintenance crew?

CHAPTER 10. ADMINISTRATION

(Lesson 5 of 5 Lessons)

10.6 PUBLIC RELATIONS

As collection system workers, the very nature of our work requires that we are in direct contact with the public in all of our daily activities. Our entire collection system is largely located either in public right of ways or in easements on private property. It could even be said that most of our public relations start with a negative element. Our services are rarely sought when everything is functioning properly. To the motorist, whose time table is upset by our activities in his right of way, our position is rarely positive. To the property owner or tenant, whose privacy is interrupted, or services disrupted, or landscaping rearranged, we can hardly be considered a positive element. We are challenged, and it can often be difficult; but through good public relations, we can convert these negative feelings into positive appreciation of our efforts.

10.61 Importance of Public Relations

A collection system maintenance organization could possibly function with little regard for its public relations. This attitude should not, however, be an acceptable philosophy. Collection systems are public utilities. As operators of such utilities, we are public servants. Public service need not imply servitude. Service should provide sincerity, courtesy and an understanding of our responsibility to the public's needs.

10.62 Aspects of Public Relations

In the course of performing our daily activities, there are many aspects of public relations to consider.

A. Telephone. In most instances initial contact with our collection system organizations will be by telephone. Relating to the well known cliche of "first impressions", it is important that this first contact be a positive one.

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1. Basic courtesy. Good practice requires that persons answering incoming calls identify the organization and give their name, clearly and sincerely. Such response should not be hurried or mechanical, it should be personable and sincere. Let the person calling know that you are interested in what they have to say.

2. Understanding. Realize the person calling, in most cases, has a problem. Try to understand their problem. Be sympathetic to their problem. Understand that they may be nervous, upset or even abusive. Your understanding and courtesy can only serve to calm them.

3. Conclusive. Whenever possible, carry the conversation to an acceptable conclusion. If the caller's problem is within the agency's realm of responsibility, assure them that a crew will be dispatched to investigate their problem. If possible, try to tell the caller how soon the problem will be corrected. If the complaint is not within your jurisdiction, help the caller find the appropriate person to contact.

4. Return calls. If the problem is of such nature to require a return call, advise the caller of the approximate time the return call will be made. If the return call is to be made by others, such as a supervisor, advise the supervisor of the approximate time interval involved that you have given the caller. Management should be sure that someone calls back to verify that the action taken met requirements or explain why not.

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B. Personal contacts. Our work demands that we have many personal contacts with the public we serve. Many such contacts will be made on their property at their home and in most cases at our convenience. Every effort should be made to make such contacts pleasant and positive for both parties.

1. Appearance. The appearance you present may, in many cases, offer a suggestion to the public, of the type of service they can expect from your organization and its workers. This appearance must be favorable.

   Workers should be provided with uniforms. The uniforms should include the name of the organization and the name of the individual. Uniforms provide for a standard of neatness as well as a means of identification.

   Equipment also should appear clean and neat. An emblem or symbol on equipment identifies your agency and helps the public to recognize workers and equipment. Informative signs on equipment help people recognize who you are and what you are accomplishing.

2. Attitude. Proper attitude cannot be overrated. Sincere concern for the problem of the individuals contacted must be demonstrated. Understand the person's problem, and perhaps the person's ignorance of the problems involved. If the problem is within your area of responsibility, advise the person as to when and how it will be solved. If the problem is not one to be handled by your department or agency, suggest proper, alternative action which the individual may take to find a solution.

3. Knowledge. Workers assigned to answering calls from the public must have and demonstrate the knowledge to effectively deal with such problems.

C. Equality. Maintain a level of equality in the level of service you provide.

1. Consistency of service level. Various organizations and agencies will provide different levels of service. For example, many agencies will be responsible only for main sewer line maintenance or repairs. House services from the building out to the sewer tap in the street or easement will be the sole responsibility of the property owner. Other agencies may assume responsibility for sewer services which lie in the right of way or easement. Whatever your agency's level of responsibility is, you should be consistent in the level of performance you provide. Often maintenance crews can be tempted to provide services beyond their responsibility. Temptation can come in a variety of forms, helpless little old ladies, pretty, amiable young ladies, or nice old gentlemen. Sometimes it is difficult for crews to refuse such pleas for extra consideration. You must try to impress your workers to give the same level of service to all customers, regardless of personal feelings or circumstances.

2. Explanation of limits of responsibility. As noted earlier, various agencies will perform different levels of service and assume different levels of responsibility relative to private and public collection systems. Supervisors must provide their workers with clear and exact guidelines as to agency policy. Employees should be able to explain such policies and areas of responsibility effectively to the public they serve.

10.63 Benefits of Good Public Relations

A. From the public. Whenever good public relations are maintained, there are many benefits to be realized.

1. Cooperation. Whenever it becomes necessary for maintenance workers to enter on private property, it is essential that the property owners cooperate. Good public relations can provide for this cooperation. Be considerate of private property at all times. Respect the public's right to privacy at all times. Never enter on private property without first notifying the occupants as to your presence and the nature of your work. Seek their permission before entering their property. If no one is home and it has been necessary for you to enter onto their property in their absence, leave a note advising them of your actions and a telephone number they can call if they have questions or complaints relative to the condition of their property after your work has been accomplished. Impress upon your workers that the impression they leave with property owners will have much effect on the cooperation given to subsequent crews should it become necessary to reenter the same property.

2. Understanding. The general public has little knowledge of the workings of a modern collection system. Few, if any, even are conscious of its location or existence, until collection system workers appear on the scene to do some needed work. Collection system workers should take the time to explain briefly the location of the system, its function, and the need for their having access to it. Shown the courtesy of such explanation, the public will be more apt to understand the nature of our work and accept whatever inconvenience we might create for them.

3. Satisfaction. Collection systems must be operated to the satisfaction of the public they serve. Public relations that are effective can have an important influence on such satisfaction.

B. To employees. Employees too will benefit from good public relations.

1. Pleasant working conditions. A good relationship with the public has to result in more pleasant working conditions for collection system workers. Being welcomed as conscientous, considerate, courteous, and essential workers, as opposed to being resented as incompetent, inconsiderate nuisances, will make the collection system worker's job more pleasant.

2. Recognition. Effective public relations will result in individual workers being recognized and commended by the public for work well done. Such recognition, when given, benefits everyone. The public appreciates the level of service which warrants such recognition, management feels its objectives and responsibilities are being carried out, supervisors are assured their efforts have not been in vain, and the worker is justly proud of a job well done.

3. Morale. Public relations of a quality which produce cooperation, understanding, satisfaction, pleasant working conditions and recognition, have to improve the morale of the maintenance organization. The benefits to be had from such high morale will make any efforts of the supervisor to maintain such a quality of public relations well worth the time and concern.

4. Self-perpetuating. Once established as normal procedure, good public relations and high employee morale become self-perpetuating. Well satisfied public is eager to cooperate and workers whose efforts are recognized and are constantly striving to improve their performance.

QUESTIONS

10.6A Why are public relations important to collection system workers?

10.6B Describe how you should respond to telephone complaints?

10.6C How can a worker make positive personal contacts?

10.6D Why is equality of service important?

10.6E Who benefits from good public relations?

10.7 REPORT WRITING

Before proceeding with this section it seems appropriate to examine the heading "Report Writing", more closely. How does this concern the collection system supervisor? When will you be expected to become involved in such writing activities? A supervisor should have the ability to prepare a written account relative to the operation and maintenance activities under the supervisor's responsibility. A report is a means to communicate information from the individual who has it to those who need it. Collection system workers are paid because somebody documented that the workers accomplished something.

REPORT WRITING

If you are a new worker to the wastewater field, you will be involved in report preparation from the beginning. Your field notes and report forms are usually the basis of information used by your supervisor to prepare written reports. Field notes or report forms are useful only if they are complete, brief and clear.

Take a few extra minutes when each job is completed to fill out forms or field notes to produce a clean, neat, readable report of the job just finished. A field report that cannot be read due to poor handwriting or poor printing, misread numbers, or writing smeared with mud is of no use to any agency. When a field form has been completed, a review by another crew member provides an easy check for legibility, correct identification of location (including street address), map references, size of lines, proper agency cost accounting codes, amount of time spent on job, and other important facts.

When you become a supervisor you will appreciate neat appearing field reports from your crews. You must develop the ability and pride to make your own reports neat and legible the first time, because if you don't, you are going to have to do them over again.

When faced with this prospect of preparing a written report, a supervisor may experience a feeling of apprehension or inadequacy because of what the supervisor may believe to be a lack of writing skill. Supervisors with many years of valuable experience and considerable knowledge and ability in the wastewater collection field, may reject the idea of putting their knowlege in writing because of this feeling of inadequacy as a writer.

For this reason we feel the emphasis should be placed on the "Reporting" aspect of the heading of this section. The information contained in the report, the knowledge and the experience that can be passed on to others through the report, these are the true objectives of "Report Writing". Your reports tell what you did to justify a public investment in your organization and what you plan to accomplish next year. If you have not organized the information into a useable and understandable form, either your budget suffers of you could be replaced.

We are, after all, experienced wastewater collection system workers. No one expects us to be fluent and accomplished writers. The people to whom the report is directed will be more interested and concerned with what the report has to say - not in how it is written. A report must be neat, understandable, and communicate the desired message!

A good example is the very course you are reading. None of the authors are professional writers. They are experienced and well qualified collection system workers. It is true that because of the scope and the expected wide distribution of this course, trained writers have assisted in editing it from a literary viewpoint. However, the ideas expressed, the experience, the concepts offered, the true value to be found in this course, all are the product of the thoughts, experience, and writing of collection system workers.

10.71 Need for Reports

The collection system supervisor will find it necessary on frequent occasions to prepare and submit written reports relating to the variety of maintenance activities which are carried on under the supervisor's direction. A variety of reasons can make such reports necessary.

Information and education are two important areas that will require written reports by supervisors. In the course of your daily activities, a supervisor will acquire a vast amount of knowledge and information that will need to be passed on to others.

1. Management. They will look to the supervisor for the information they need to assist them in making various management decisions such as planning, staffing, budgets, equipment and program control.

2. Workers. They look to their supervisor for the information and training needed to perform their job effectively. Reports by the supervisor relative to various maintenance programs and procedures which explain their success or shortcomings can be useful in the education and training of employees. Such a written report, after it has been prepared, will be of more value if given orally to the workers. This will encourage more detailed discussion and explanation of each particular maintenance activity and allow for a better understanding of why it did or did not accomplish the desired objectives.

3. Public. As modern collection systems grow and become more sophisticated, they also are becoming more expensive to maintain. They also are increasing in value as a capital investment. All this adds up to more cost to the tax paying public. Increased taxes bring an increase in public awareness. There is corresponding public concern for how their tax money is being spent. For these reasons it is becoming more necessary for supervisors to prepare reports or to appear at public meetings to explain their activities and justify their existence and efficiency.

4. Other agencies. Throughout the nation there are wastewater collection system and wastewater treatment associations which conduct periodic conferences and meetings for the purpose of exchanging ideas and

experiences. These associations are a valuable source of training and education for people in the field of the operation and maintenance of wastewater collection systems. Supervisors will frequently be asked to participate in such activities and prepare reports to be presented at these gatherings. Helpful professional organizations include the Water Pollution Control Federation and the American Public Works Association. Both of these organizations have regional, state and local organizations.

QUESTIONS

10.7A What is the purpose of report writing?

10.7B Reports must be prepared to inform what types of groups?

10.7C Why should reports be prepared for workers?

10.7D Why should reports be prepared for the public?

10.72 Types of Reports

There are many types of reports which may become of concern to the collection system supervisor. The size and scope of the supervisor's responsibility and activities will have an influence on the number and variety of the reports that may be required. The three main types of reports are report forms, written reports, and oral presentations.

A. Report forms. The simplest and the most common type of reports are those which can be completed and submitted on forms that have been designed for a specific purpose.

Much of the information necessary for the supervisor to complete the required forms will come from reporting forms completed and submitted by the workers.

In many instances it will be necessary for the supervisor to become involved in the design of such forms. The supervisor may have to devise and design such forms as are necessary to enable foremen or other workers to report all the information needed to operate and administer a particular area of responsibility effectively and efficiently.

Another aspect to be concerned with is that such forms be limited to information and activities that are essential to the effective operation of the supervisor's organization. Reporting forms should be periodically reviewed, at least on an annual basis, to insure their essential qualities. As time passes, programs and activities change and some forms may become nonessential. These forms should be discontinued. Limiting the required number of forms to those that are absolutely essential will usually result in a more conscientious attitude and concern for accuracy by workers who are required to complete and submit such forms.

1. Production. A primary concern for any supervisor is crew productivity. The supervisor must be kept informed at all times on the progress and production of the workers. Management may require submission of reports substantiating production. Areas of concern may include:

   a) A monthly report from each individual foreman. This report should include on a daily basis the production of each of the crews under each foreman. Activities involved may include balling, rodding, TV inspection, construction and repairs, or any other significant maintenance activities that are part of the organization's maintenance program.

   b) A monthly report reflecting the unscheduled work load. This report should indicate the number of calls answered. It should indicate the number of main line stoppages encountered. Stoppages should be listed according to their cause such as roots, grease, or other appropriate designations you may desire.

A suggested sample of a simple form is shown in Figure 10.14. This form can be modified to meet the needs of your particular maintenance organization.

In Figure 10.14, Units 3, 4, and 6 are regular 8-hour work day field service units. All three of the units operate during the regular 8:00 a.m. to 5:00 p.m. working hours. Unit 49 is whichever of Units 3, 4, or 6 that is on call from 4:00 p.m. through 8:00 a.m. and on weekends and holidays as the stand-by duty vehicle. All three of these units are radio units and all workers in the system know that whoever is designated as Unit 49 is the service request crew.

There are many advantages to be had through the use of a simple form such as the one illustrated. They provide an immediate accounting of the previous month's work load. More importantly, when recorded monthly, these forms over a period of years will provide an accurate indication as to the seasonal trend of your unscheduled work load.

2. Budget. Most supervisors will have a degree of responsibility in the preparation and submittal of the budget for their organization. Many budgets may require or consist of merely completing budget forms provided by management or accounting departments. All budgets will require information relative to production or anticipated work loads. The above mentioned reporting forms will be very helpful in providing such information and figures.

Date ______________________

	Unit 3	Unit 4	Unit 6	Unit 49	Total
Service Requests					
Main Line Stoppages					
(Roots)					
(Grease)					
(Other)					
Service Line Dig Ups					
Rod C/O to Main					
Owner's Problem					
Flooded Home					
Miscellaneous Service Requests					

Fig. 10.14. Monthly report summarizing unscheduled work load

3. Personnel. Report forms relative to workers are basic in nature and in most organizations the primary concern of a personnel or accounting department. However, some reporting forms relative to workers that could be of direct concern to the supervisor may include:

   a) Performance reports.

   b) Accident reports.

   c) Attendance analysis reports. An attendance report per se may not be very informative. An analysis of that report by a supervisor may indicate a pattern of absences which would suggest some corrective action on the part of the supervisor to be advisable.

4. Cost of operation. A report on how budgeted funds are spent is very important. This report should describe the total cost of operation and include costs for supplies, materials, equipment and salaries. Costs also can be divided into the types of programs such as clearing emergency stoppages, preventive maintenance, responding to complaints and repairs.

5. Problems. A record of problems encountered is important so problems can be anticipated or prevented from occurring in the future.

B. Written Reports. This type of report requires you to explain an idea or an accomplishment to a group of persons. There are a variety of situations which could arise that would require a report to be prepared by a collection system supervisor. We can suggest a few.

1. Your collection system organization has developed and initiated a preventive maintenance program. This program has been on-going for a period of years. You could be asked to explain its operation and its effectiveness.

2. You have just completed a smoke testing operation covering a large area and requiring considerable time and money. What were the benefits or results? What corrective measures were indicated or undertaken?

3. Recent acquisition of TV inspection equipment has made possible an inspection of a significant portion of your collection system. What did it reveal? Will it change your method of maintenance procedures?

4. An infiltration/inflow study has recently been completed. What did it reveal?

5. Chemical treatment for root control has been made a part of your maintenance program. How is it accomplished? Is it effective?

6. A major pipe rejuvenation project has just been completed, such as sealing and pull through liners. How was it accomplished? What were some of the difficulties encountered relative to traffic disruption and public inconvenience? Do you have suggestions on how your agency or someone else could do a better job next time?

7. Or, you may simply be asked to explain your collection system operation and maintenance organization, its functions, its effectiveness, its benefits and its importance to public health and safety.

C. Oral presentations. As with written reports, many collection system supervisors may feel reluctant to give an oral presentation. This too, is understandable. Just as few of us in the collection system field are accomplished writers, so too are few of us experienced public speakers.

However, it is a situation to be contended with by qualified collection system supervisors. If they are successful in writing an interesting, educational, productive written report, it becomes quite probable they will be invited to present that report orally to some interested group.

Here again, the apprehension you may feel is probably unfounded. The group you are to address in all probability is not coming to hear a "speaker". They came to hear what is to be said. If your talk is timely, and your facts informative and interesting, the delivery will assume secondary importance to the group in attendance. If you wish to practice public speaking or to try to improve your presentation, Toastmasters or other similar organizations can be very helpful.

D. Publication of reports. An interesting and informative written report may qualify for publication in a trade publication. This would be especially true if the report was well received when presented orally to a representative group.

At this point the supervisor who wrote the report can relax. Professional editors for the publication will review and edit the report. You can experience a feeling of pride, in that your work has been judged to be of a quality to warrant wide-spread distribution. This can be your reward for all the prior apprehension and feeling of inadequacy you experienced.

QUESTIONS

10.7E What are the three main types of reports?

10.7F How would you prepare a form?

10.7G What types of report forms do collection system workers use?

10.7H What kinds of activities could be reported in a narrative type report?

10.7I Why should oral reports be given?

10.73 How to Prepare a Good Report

Perhaps the heading for this paragraph should be: "What goes into a good report?" This is where our emphasis is going to be placed. As stated before, qualified technical writing reference material is your best source for the how of writing. However, there are a few basic steps we can suggest in the preparation of a good report.

A. Organization. Before you can organize your report you must first organize yourself and your thoughts. Ask yourself, what is to be the objective of this report? For whom is it being written? What information or experiences do I have to relate? How can I make them of interest to the particular group for whom the report is being prepared?

1. After you have answered the above questions, the next step is to prepare a general outline of how you intend to proceed with the preparation of the report.

   The outline should include all the information you have on the subject to be presented. Arrange the outline to present the facts in a sequence that will be logical and easily understood.

   An important fact to remember when preparing your outline is to include all the information you consider to be necessary. Do not attempt to make your outline perfect. Your outline is just a guide. It should be flexible. It is better to include too much material in your outline.

   List topic material only in your outline. Try to list all of the topics. Next decide the order of topics and group the topics under major headings. Arrange the topics so there is a workable, smooth flow from one topic to the next topic. You will find that as you begin to write you will remove non-essential points and expand on the more important points. Follow the outline to avoid repeating material.

2. Tailor the report to the reader. This is very important. The report should contain points of information that will interest the particular group to which it is to be offered. Place back up material and field data in an appendix if appropriate.

   We can suggest, in detail, some examples relative to this aspect of report writing. Assume you have completed or plan to complete a smoke testing program. You also are to prepare a written report covering these tests. How should you prepare the report to be given to different groups? Management? Citizens group? Other collection system agencies?

a) Management. They will have specific interests, mainly related to cost effectiveness. A report to management should include:

   1) Summary giving essentials (one page at most).

   2) Procedures used or method of study.

   3) Analysis of data, including trends.

   4) Summary and conclusions.

   Management may only read items 1 and 4 so be sure the essential information you wish to communicate is clear and brief. Be sure to give complete cost figures. Did the benefits warrant the costs? As a result of the tests, can future expenditures be reduced? Back up information and field data can be placed in an appendix for those who need the details.

b) Other collection system agencies. They too will be interested in cost figures. They also will want to know how the tests were accomplished, the procedures involved, size of crew required, type of equipment required, source and availability of equipment and materials needed, difficulties encountered and how they were solved. The results and the benefits to be realized are important too.

c) Citizens group. Their interest will be more basic. What is a smoke test? Why is it needed? Is the smoke harmless? Will it injure their plants or pets? Must they be home when the tests are in progress? How does the smoke detect defects? If illegal connections are found, how will this affect the individual property owners? Will it inconvenience them? Who pays for the test? How much will it cost to repair defects?

Each of these reports could be prepared using your original general outline. Simply adjust the outline to best emphasize the particular points you feel would be of particular interest to each specific group involved.

B. Composition. In the composition of your report it is wise to keep in mind the purpose of your writing. You are not writing a story. You are writing a "Report". Confine your writing to the activities that took place, the experiences gathered, and the results achieved. Be honest and explain the advantages and limitations of any recommendations.

1. Drafts. Don't expect your report to be perfect the first time. Follow your outline and write a rough draft. Maybe you should be concerned with putting down your ideas the first time. Reread your draft three to five days later. Critically think about what you are saying. Ask a friend to read your report. Reread it and consider the items listed in the remainder of the section. Each time you rewrite a portion it will become a little bit better. We rewrote this manual seven times after we received comments and suggestions from many groups.

2. Factual. Confine your writing to the facts and events which occurred. Include only figures and statistics necessary to make the report effective. Facts must be accurate to allow for proper interpretation in the summary, conclusions and recommendations. Do not clutter the report with a lot of irrelevant figures that had little influence on the end results. Place data in an appendix.

3. Continuity. To be interesting and easily understood, a report must have continuity. You had a problem, you explored various means to identify the problem -- where it was located, what it was -- and determined the needed correction. Consider the example we offered relative to the smoke test.

A problem condition of excessive infiltration or inflow was discovered. Smoke testing offered the prospective means of identification and location of points of inflow. Funds, equipment, and material were acquired. Workers were trained. Tests were made. Results and conclusions reached. Corrective actions were planned and taken. Conclusion, the tests did or did not produce the anticipated results or correct the problem.

4. Effective. To be effective, a report should produce the objective for which it is designed. In our example we wanted to justify to management that the tests were cost effective. To the other agencies, we wished to share our experience and knowledge in a way that would be of benefit to them. To the citizens group, we wanted to educate them as to what we were attempting to accomplish with our tests and explain the direct benefits to be realized by the public involved.

   Effective reports require that you present clear, concise facts in a logical sequence (continuity) that can be easily understood by the group to which they are being offered.

   As an example of how you can easily be tempted to deviate from these basic principles, consider the report to the citizens group. They will have little knowledge of how a modern collection system functions. It would be easy for you to wander from your main objective by attempting to explain your collection system in detail. Certainly they would be interested in such aspects as lateral lines, main lines, trunk lines, lift stations, velocities, gravity lines, force mains, maintenance problems such as roots, grease, and debris, maintenance procedures, maintenance equipment, and your entire operation. It would all be very interesting to them but, it was not the object of your report. A brief explanation of how excessive inflow overloads treatment facilities and results in increased treatment costs is all that is required to put across the main objective of your report and the reason for the smoke test.

5. Candid. Webster's definition of candid is "frank, straight forward." A good report must have this quality. You are aware of your capabilities and experience. Keep your report within these limits. Do not attempt to impress a group such as management or professionals by using language or terminology that is unfamiliar to you. Likewise, with citizens groups do not attempt to impress them with language familiar to you, but foreign to them.

   You want your report to accomplish the objective for which it was intended. To do this it must be favorably accepted by those to whom it is presented. Candor, honesty, sincerity, frankness will contribute greatly to the acceptance you seek. Anything less can only serve to detract from your report and may invite unwanted skepticism or criticism.

QUESTIONS

10.7J What are some basic steps to follow when preparing a report?

10.7K Why is a good outline essential?

10.7L Why must the intended readers of the report be considered?

10.7M What is the purpose of preparing drafts of reports?

10.74 Additional Reading

1. Gribkoff, George, "Records and Report Writing," Chapter 17 in Operation of Wastewater Treatment Plants by Kerri, K. D., and Dendy, B. B., California State University, Sacramento, Department of Civil Engineering, Sacramento, California, 95819. Price for 17 Chapter manual, $25.00.

2. Stockwell, Richard E., "The Stockwell Guide for Technical and Vocational Writing," The Cummings Publishing Company, Inc., 2727 Sand Hill Road, Menlo Park, California 94025, (1971), 296 p. Price $6.25. Accompanying Workbook, 129 p. Price $2.95.

3. Ulman, J., "Technical Reporting," 3rd Edition, Holt, Rinehart and Winston, Inc., 383 Madison Avenue, New York, New York 10017. Price $10.95.

4. Baker, Sheridan, "The Complete Stylist," 2nd Edition, Thomas Y. Crowell Shipping Service, 788 Bloomfield Avenue, Clifton, New Jersey 07012 (1966). Price $6.50.

5. Flesch, Rudolf and Lass, A. H., "A New Guide to Better Writing," Popular Library, Reader Service Department, Post Office Box 5755, Terre Haute, Indiana 47805 (1963). Price $1.15.

10.8 PEOPLE

How does the manager or administrator deal with people? Every day we have to work with our supervisors, the public, the people we work with and the people who work for us. In this manual we have tried to outline how to get the job done, how to create a climate for good morale and how to provide training opportunities for workers.

A very highly specialized field has developed on how to motivate, deal with people and how to supervise or manage people working for you. We believe this is a special topic and we have decided not to expand our presentation on this subject. If you have a need for or wish to learn more on how to deal with people, we suggest enrolling in courses or reading books on supervision or personnel management.

10.9 ACKNOWLEDGEMENT

Many of the maps, forms and procedures presented in this chapter were developed by the Water Quality Division, Sacramento County, Sacramento, California. We sincerely appreciate and acknowledge the County's contributions to this chapter.

END OF LESSON 5 OF 5 LESSONS ON ADMINISTRATION

DISCUSSION AND REVIEW QUESTIONS

CHAPTER 10. ADMINISTRATION

(Lesson 5 of 5 Lessons)

Write the answers to these questions in your notebook before continuing with the Objective Test on page 10-171. The problem numbering continues from Lesson 4.

28. How does the collection system worker come in contact with the public?

29. What does "public relations" mean to you?

30. Why are public relations important to the collection system worker?

31. Why must the same level of service be provided for everyone?

32. Why are reports important?

33. How would you prepare and write a report for your supervisor?

34. Why are oral reports effective?

SUGGESTED ANSWERS

CHAPTER 10. ADMINISTRATION

10.1A The most important aspects of effective administration or supervision for persons working with wastewater collection systems include:

1. Mapping,
2. Records,
3. Scheduling of Maintenance Work,
4. Staffing Requirements,
5. Tool and Equipment Requirements,
6. Public Relations,
7. Report Writing,
8. People.

10.1B Maps of a wastewater collection system are important because they show:

1. Where the system is located.
2. The size of the collection system pipes.

10.1C Information required on wastewater collection system maps includes:

1. Locations,
2. Identification,
3. Elevations,
4. Footage or distances,
5. Type of pipe,
6. Flow direction,
7. Force mains,
8. Soil conditions,
9. Properties connected to collection system,
10. Inventory,
11. Date.

10.1D All manholes should be identified by a specific number and/or letters and this identification should never change.

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10.1E The essential elevations that should be shown on collection system maps include:

1. Flow lines or invert elevations at the site of each manhole.
2. Manhole rim elevations.
3. Depth of pipe line.
4. Depth of house service line at property line.

10.1F Soil conditions are of great importance and a significant safety factor to future repair crews who have to dig in disturbed ground.

10.1G Assessor's maps contain the most detail.

10.1H Maps must be updated to maintain their usefulness and to reduce time consuming and costly mistakes.

10.1I Maps can be kept up to date by:

1. Annual updating of all changes and corrections.
2. Recording changes when they occur.
3. Field workers (maintenance and inspectors) reporting all changes and discrepancies.
4. Field checking existing maps with actual conditions in the field.

10.1J Maps can be used as a maintenance record by showing:

1. Problem areas
2. Maintenance activities
3. Proposed maintenance schedules

10.1K Problem areas can be shown on a map by using colored pins or colored codes on the map that indicates the type of problem (roots, grease) and frequency of the problem.

10.2A Records are necessary because they provide a:

1. Record of the past.
2. Sound basis on which to plan the future.

10.2B Cost items that should be recorded include:

1. Labor,
2. Equipment,
3. Supplies,
4. Services.

10.2C Records are very important when preparing a budget. Accurate records detailing last year's activities, costs, work load, growth and production (such as miles of lines cleaned) can be the best justification for next year's budget requests.

10.2D The best protection against legal action or liability claims is reliable records to verify that recommended procedures were followed and that no one was negligent in meeting their responsibility.

10.2E An individual's fact sheet should contain information on age, blood type, innoculations, dependents and medical history for use in case of accident or serious injury. This file must be updated annually.

10.2F 1. Telephone logs should be kept to record all telephone calls received, especially calls from the public which require some action or response by your agency.

2. Radio dispatcher's log records nature of calls from field crews and instructions or requests for information sent to field crews.

Logs are very important because they provide documentation of exactly what happened if there is a controversy or legal action.

10.2G A card for recording complaints should have spaces for the following information:

1. Address ______________________________
2. District ______________________________
3. Manhole # ____________ to ____________
4. Assigned to ____________ Date ____________
5. Time Received ________ Time Arrived ________
6. Work Done ______________________________
7. Recommendation ______________________________
8. Street ________ Easement ________ Recorded ________
9. Time Completed ________ Signed ____________

10.2H A good public relations practice is to contact the person who filed the complaint after the problem is corrected. This action can determine if the person who filed the complaint is:

1. Aware that the problem is corrected,
2. Satisfied with the corrective action, and
3. Willing to offer any suggestion on how your agency can better serve your customers.

10.2I Follow-up work order forms are completed by crews that go out into the field and try to correct a problem or complaint. The corrective action may be only temporary and this crew or another crew may have to return to the location at a more convenient time and make permanent repairs. The follow-up work order is a record that indicates more work is required.

10.2J Forms must be brief and simple so they are easy to complete and file. Cluttered forms with many boxes and spaces that are rarely used are not very efficient.

10.2K Production records list the activity and accomplishments of your agency, including:

1. Number of complaints received and corrected.
2. Types of complaints (stoppages and cause, odor complaints).
3. TV inspection footage.
4. Balling footage.
5. Rodding footage.
6. High velocity cleaner footage.
7. Main line repairs.
8. Manhole repairs.

10.2L A foreman or a crew leader should keep a diary to record unusual happenings or information which may occur and for which no other reporting form is provided.

10.2M Everyone is responsible for being sure the agency has a good record keeping system.

1. The supervisor must be sure the proper records are kept, that the records are useful, and that field and office workers comply with record keeping policies.
2. Field workers must be sure that all information recorded is accurate, neat, promptly written on the forms, and in compliance with agency standards.
3. Office personnel must be sure that all records are promptly and properly filed. A familiarity with the nature of field work will help to encourage cooperation between office personnel and field workers and to improve the usefulness of the records.

10.2N Good records demonstrating or documenting performance are the best measures of effectiveness and justification for budgets available to a supervisor.

10.3A Undesirable conditions caused by overflows and discharges of wastewater can be minimized or eliminated by the use of modern, specialized maintenance equipment and well planned maintenance scheduling.

10.3B A preventive maintenance program is a total concept that includes functional maps, good records and intelligent use and assignment of available staff and equipment. Scheduling of maintenance activities is well planned and meaningful. The objective of preventive maintenance is to improve existing conditions in problem areas to a point where scheduled maintenance can be significantly reduced or ultimately eliminated.

10.3C To prepare an effective schedule for maintaining a wastewater collection system, a knowledge of the collection system, maintenance procedures, and available equipment and manpower are very important. Actual maintenance schedules must attempt to schedule jobs only when needed. Effectiveness of the maintenance program must be continuously evaluated and schedules adjusted as necessary.

10.3D A person can become familiar with a collection system by studying maps and records; actual field experience is very important too.

10.3E Important time factors that must be included when developing a maintenance program should be when will the work be needed and to be sure the work is not scheduled too frequently.

10.3F Maintenance schedules should be adjusted in accordance with the results the schedule has or has not produced.

10.4A The single most important factor that influences the size of staff is the size of the collection system to be maintained. Other important factors include age of system, condition of system, types of wastes being discharged, temperatures and population growth rates.

10.4B Use of formulas and charts will suggest staffing size on the basis of average conditions. Staff size should be based on an analysis of work load, objectives, and funds available.

10.4C Maps can help determine manpower requirements in the following ways:

1. Accurate maps reduce wasted time in the field looking for items that should be on maps. If maps are inaccurate, try to obtain staff to update and improve accuracy of map.
2. Maps show locations of manholes and accessibility for workers and equipment.

10.4D Records show what was accomplished in the past and whether or not past activities produced the desired results. Records show extent and location of problem areas.

10.4E Objectives are very important. We establish target objectives of performance and production. When we identify what we wish to accomplish, we then try to determine the staff needed to attain our objectives.

10.4F Factors that could hinder efforts to obtain a desirable crew size include:

1. Limited funds.
2. Poor records that are unable to justify the desired crew size.

10.4G Crews tend to specialize in larger systems because there are more crews and each crew is more apt to do a similar job every day, thus becoming specialists in the jobs they do most frequently.

10.4H The basic crew in most maintenance organizations is the emergency crew.

10.4I Emergency crews usually consist of two workers. Under these conditions, neither worker should ever enter a manhole unless a third person is available.

10.4J Other activities conducted by an emergency crew when there are no emergencies include inspection, repair, map checking, location of inflow/infiltration, and scheduled maintenance jobs.

10.4K The number of balling crews and the extent to which they are used is determined by the size of the collection system and the conditions within that system.

10.4L Balling crews also can function as a repair crew, chemical crew, bucket machine crew, or smoke testing crew.

10.4M High velocity cleaners are commonly used all of the time.

10.4N No. CCTV equipment available today can be operated effectively by existing collection system workers with adequate training.

10.4O Crews should be rotated from job to job so trained crews are available at all times for any job and so crew members can be transferred from one crew to another if a key worker in one crew becomes ill or the opportunity for promotion develops.

10.4P Smoke testing crews try to locate and identify points of inflow and illegal connections.

10.4Q Repair crews deal primarily with replacement of defective portions of the collection system, while construction crews are engaged in new work.

10.4R Safety requirements have required increases in the amount of staffing.

10.4S Safety requirements prevent either person on a two-worker crew from entering a manhole on those occasions when it becomes necessary for one of the two workers to enter a manhole, a foreman can be called to act as a third worker.

10.4T Maintenance crew members must be properly trained so they can effectively accomplish the tasks they are assigned. Effectiveness is indicated by the job being properly done quickly and safely.

10.4U Maintenance crew members can be trained on the job, by reading trade magazines and papers, by formal classroom training, by attending professional meetings, and by home study.

10.4V Maintenance crews should be given information that will:

1. Help with their continuing education (including safety), and
2. Indicate to them the results they have achieved.

10.4W The purpose of an annual meeting is to tell maintenance crews what their year's efforts have produced.

10.4X To select the best applicant for a job, decide what a worker needs to know and be able to perform the job. Try to match the applicant's ability with the demands of the job. Consider the applicant's experience, education, personality, and potential.

10.4Y The key to a good employment selection interview is to put the applicant at ease.

10.4Z The supervisor and the shop steward should try to cooperate and work together. The supervisor is management's link with the workers and the shop steward is the workers' link with management.

10.5A Tool and equipment requirements can be determined on the basis of size of collection system, work load, and objectives. Equipment selection should be based on the type or types of problems you want the equipment to solve.

10.5B Most modern collection system maintenance equipment has one particular function that it does most effectively.

10.5C The shotgun approach is not recommended because it is wasteful and unnecessary. Equipment should be used in those areas where it is most needed.

10.5D Equipment to implement a preventive maintenance program can be obtained through long or short term leasing or by contracting for a specialized job, rather than by outright purchase if not enough money is available.

10.5E Advantages to equipment leasing include:

1. Expensive equipment can be made available without an initial capital expenditure of considerable amount.
2. Specialized equipment is made available to the agency, at a reasonable cost, to complete any one-time or seasonal programs.

10.5F Advantages of purchasing include:

1. Standard equipment that is used continuously with a long life span for a reasonable price.
2. Equipment is available when needed.

10.5G Contracting for work can be advantageous when an agency does not have sufficient qualified or qualifiable staff available to do a highly specialized job. Also the agency does not have to buy equipment that will not be used continuously.

10.5H Emergency crews should be provided with at least a 3/4-ton truck.

10.5I The following crews should be equipped with two-way radios or paging devices:

1. Emergency crew.
2. Rodding truck (one crew).
3. Repair crew.

10.5J A truck with adequate capacity must be specified so the truck will not wear out before the high velocity cleaning equipment. If a truck is of marginal capacity, the truck could be in use for a period of time before problems start developing such as brake problems, weakened springs, difficult road handling, and a loss of engine power.

10.5K Truck mounted units are preferable for units that are used on a full-time basis while trailer mounted units are desirable for equipment used on a part-time basis because the truck pulling the trailer can be used for other purposes when the trailer mounted unit is not in service.

10.5L Portable stand-by pumping units should be inspected and run at regular intervals to assure they will be in operating condition when an emergency does arise.

10.5M Major pieces of equipment needed for construction and repair includes backhoe, dump truck, water truck, portable air compressor, and hoists.

10.5N Portable air compressors are to operate jack hammers and tampers.

10.5O One complete unit may be purchased that will provide for television inspection, air testing, and joint sealing as a package mounted on a truck or trailer unit.

10.5P Seldom used equipment such as large size sewer balls and portable emergency pumps must be stored at a location that is accessible to the crews when the equipment is needed.

10.5Q Three different types of electronic locators include:

1. Simple valve or lid locator.
2. Pipe locator.
3. Ferret type.

10.5R The two different types of plugs are air plugs and mechanical plugs.

10.5S Hand-made taps should be discouraged because they often result in broken sewers, ill-fitting taps, and taps protruding into the sewer. These problems provide inviting areas for future root intrusion and for a person to use an excess of cement or grout in an effort to hide the whole crude job.

10.5T Taps protruding into sewers can be removed by use of an internal tap cutter that is manually pulled through the inside of a pipe. The protruding tap is cut off by use of a core drill.

10.5U Service lines can be placed under a major thoroughfare without disrupting traffic by boring a hole for the line under the thoroughfare.

10.5V Atmospheres that require testing before entering include confined spaces such as manholes and wet pits.

10.5W The three main items of concern when testing an atmosphere are:

1. Lack of oxygen,
2. An explosive condition, and
3. Toxic gases.

10.5X The atmosphere must be monitored continuously because the atmosphere can change suddenly.

10.5Y Fresh air can be introduced into confined spaces by the use of blowers.

10.5Z The different types of shoring include:

1. Hydraulic shoring.
2. Manual shoring consisting of screw jacks and wooden timbers.
3. Sheet shoring.
4. Cylinder and shield shoring.

10.5AA Traffic control is often overlooked or underrated because crews occasionally get in a hurry and/or careless.

10.5AB Collection system workers must wear protective clothing to protect themselves from unnecessary exposure to the hazards of their job. Protective clothing includes uniforms, safety shoes, rubber boots, rubber gloves, eye protection, hard hats, and safety harnesses.

10.6A Public relations are important because we are always in contact with the public. Our service should be sincere, courteous and understanding in spite of trying circumstances.

10.6B Responders to telephone complaints should try to make a good first impression. When answering the phone, identify yourself, be personable and sincere. Try to be understanding and sympathetic towards the caller's problem. Conclude the conversation with an acceptable solution and when the problem will be solved. Follow up with a return call if necessary.

10.6C Positive personal contacts can be made by having a neat appearance, such as wearing a uniform or clean work clothes. A proper and sincere attitude towards other people is very helpful. A knowledge of how to solve the problem is impressive.

10.6D Equality of service is important because if everyone is not given the same level of service, then everyone will want special service or favors beyond the responsibility of your agency. This extra service is time consuming and costly to the taxpayer.

10.6E Everyone benefits from good public relations. The public will cooperate with your agency, understand what you are trying to do, and hopefully be satisfied with your services. Employees benefit from pleasant working conditions, recognition of their efforts, high morale and a satisfied public.

10.7A The purpose of report writing is to report information. Most important is what the report has to say.

10.7B Reports must be prepared for management, workers, public, and other agencies.

10.7C Reports should be prepared for workers to inform them of maintenance programs and procedures, and explanations of their successes or short comings. This report may be of more value if given orally to the workers.

10.7D Reports should be prepared for the public to explain your agency's activities and justify your existence and need for financial support or taxes.

10.7E The three main types of reports are:

A. Report Forms,
B. Written Reports,
C. Oral Presentations.

10.7F When preparing a form, be sure all information requested is essential. Periodically (once a year) review all forms to insure only essential information is collected and that important information is not overlooked.

10.7G Collection system workers use report forms to collect and present information on:

A. Production,
B. Budget,
C. Personnel,
D. Cost of operation,
E. Problems.

10.7H A written report could present the results of a new preventive maintenance program, a smoke testing program, a TV inspection of a sewer, an infiltration/inflow study, a chemical treatment program for root control, or a pipe sealing program.

10.7I Oral reports give you a chance to tell others of your knowledge. Often people have similar problems and like to exchange ideas regarding solutions.

10.7J Basic steps to follow when preparing a report include:

A. Organization.
B. Composition.

10.7K A good outline helps to organize the report and present information in a logical sequence that is easily understood.

10.7L The intended readers of the report must be considered because different readers have different backgrounds and desire different information.

10.7M Drafts of reports help to review the report, let others look at it, and give you a chance to improve or "polish" the report.

OBJECTIVE TEST

CHAPTER 10. ADMINISTRATION

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

1. Information required on maps includes:

    1. North arrow.
    2. Elevations.
    3. Type of pipe.
    4. Flow direction.
    5. Date map prepared and revision dates.

2. Maps are needed to:

    1. Prepare maintenance programs.
    2. Plan activities for crews.
    3. Make parachutes to pull tag lines down sewers.
    4. Show locations of facilities.
    5. Cover office walls.

3. Maps must be kept up to date so:

    1. Costly and time consuming mistakes will be reduced.
    2. The assessor will not get lost.
    3. Crews will know exact field conditions.
    4. Paper work won't pile up.
    5. Vacation schedules can be planned.

4. In general, records fill two basic needs: (select the best answer)

    1. They record what was done and when it was done.
    2. They record who did it and why it was done.
    3. They record the past and provide a sound basis on which to plan the future.
    4. They record where we've been and how we got where we are today.
    5. They record how much money was budgeted and how much was spent.

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5. Types of records needed to operate and maintain wastewater collection systems include:

   1. Personnel.
   2. Production.
   3. Costs.
   4. Guinness Book of Records.
   5. Equipment maintenance.

6. A telephone log of a complaint should contain:

   1. Nature of complaint.
   2. Sound of caller's voice.
   3. Time call received.
   4. Name of person assigned to investigate.
   5. Sex of caller.

7. A foreman's monthly report should include:

   1. Number of monthly reports prepared.
   2. Number of complaints received and investigated.
   3. Last time supervisor read report.
   4. Number of stoppages cleared.
   5. Production of each crew.

8. Records must not only be collected, but they must be:

   1. Filed and used.
   2. Played.
   3. Neat.
   4. Accurate.
   5. Broken.

9. Different types of maintenance programs include:

   1. Emergency.
   2. Operation.
   3. Typical.
   4. Public.
   5. Preventive.

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10. Factors essential for planning a maintenance schedule include:

    1. Timing of activity.
    2. Objective of activities.
    3. Desired effectiveness of schedule.
    4. Knowledge of collection system.
    5. Knowledge of maintenance procedures and equipment.

11. Staffing requirements should be based on:

    1. Comparisons with other cities.
    2. Charts developed by consultants.
    3. Work load.
    4. Objectives.
    5. Size and condition of collection system.

12. Size of crew depends on:

    1. Type of activity.
    2. Number of qualifiable workers available.
    3. Type of equipment.
    4. Safety regulations.
    5. Need to direct traffic.

13. Sources of training for crew members include:

    1. Elementary school.
    2. Short schools.
    3. On the job.
    4. Trade magazines and papers.
    5. School of hard knocks.

14. Tool and equipment requirements depend on:

    1. Size of collection system.
    2. Effectiveness of salesmen.
    3. Type of equipment.
    4. Objectives.
    5. Size of tool boxes and compartments.

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15. Safety equipment for field crews includes:

    1. Air testing meters.
    2. Chlorine testers.
    3. Blowers.
    4. Traffic control equipment.
    5. Protective clothing.

16. Public relations are important because we:

    1. Need lots of training.
    2. Want to finish our work in a hurry.
    3. Must deal with the public.
    4. Like our jobs.
    5. Work for the public.

17. Good public relations include:

    1. Making a good "first" impression.
    2. Providing an equal level of service to everyone.
    3. Having someone do your public relations.
    4. A neat appearance.
    5. The proper attitude.

18. Who benefits from good public relations?

    1. Public.
    2. Federal Government.
    3. Employees.
    4. Management.
    5. Lawyers.

19. Reports on collection systems are needed to inform:

    1. Typists.
    2. Management.
    3. Employees.
    4. Public.
    5. Other agencies.

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20. Factors helpful for the preparation of a good report include:

1. Good literary style.
2. Organization.
3. Intended reader.
4. Composition.
5. Copying what others wrote.

Review Questions

21. Collection system workers should never attempt to install, trouble shoot, maintain, repair or replace electrical equipment panels, controls, wiring or circuits unless:

1. You know what you are doing, are qualified, and are authorized.
2. A pump is plugged.
3. A manhole is overflowing down a street.
4. A wet well is overflowing and flooding a lift station.
5. You are receiving lots of odor complaints.

22. When handling and storing lubricants, special precautions include:

1. Making sure storage area does not create a fire hazard.
2. Keeping open flames away from stored lubricants.
3. Posting "NO SMOKING" signs outside buildings storing lubricants.
4. Wiping up all spills.
5. Keeping all lids on containers tight.

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CHAPTER 11

ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

by

John Brady, John Cavoretto and George Gardin

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OBJECTIVES

CHAPTER 11. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

After completion of Chapter 11 you should be able to do the following:

1. Organize an agency to operate and maintain a wastewater collection system.
2. Identify functions of essential units within an agency.
3. Staff and equip essential units within an agency.
4. Develop priority lists for job assignments for units within an agency.

CHAPTER 11. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 1 of 4 Lessons)

11.0 DEVELOPMENT OF AN EFFECTIVE OPERATION AND MAINTENANCE PROGRAM

In the past, wastewater collection system operation and maintenance functions often were treated as something to be given attention only when an emergency developed. Today every effort is made to keep emergencies from occurring. The overall efficiency of the wastewater treatment plant can be greatly influenced by properly operating and maintaining the wastewater collection system. Full use of the wastewater collection system can be achieved by the community through a better operating system. Today's sophisticated equipment and educated workers are capable of maximizing available collection system capacity and avoiding or postponing expensive costs for expansion of the collection system.

The purpose of this chapter is to provide information to help develop an effective wastewater collection system operation and maintenance organization. Previous chapters discussed why and how collection systems are designed and constructed; methods available for cleaning, testing, inspecting; how to maintain and repair equipment and facilities; the importance of gathering collection system history and data; and the interpretation and use of recorded data. All of these factors must be coordinated, implemented, and reviewed for effectiveness to produce a comprehensive program that minimizes problems and service requests or complaints. To work effectively this program must identify the sources of the potential problems and, if possible, correct the problems. Such an organization and maintenance program will minimize the development of a nuisance or a public health hazard, but some will develop through no fault of the system due to accidents or disasters that may occur. With this attitute and effectiveness, the taxpayers of the community may be convinced that they are receiving a service from the wastewater collection system agency.

The need or opportunity to establish a wastewater collection system operation and maintenance organization from the beginning would be unusual today because most communities have an agency or program already established to provide some type of collection system maintenance. However, it is always necessary to search for new and better ways to improve our organization and procedures to increase efficiency and reduce the cost of operating and maintaining the collection system.

QUESTIONS

11.0A What should be the objectives of a modern wastewater collection system organization?

11.0B How can the material in this manual help an existing wastewater collection system organization?

11.1 DEVELOPMENT OF AN ORGANIZATION STRUCTURE

Many factors must be considered when developing or modernizing the structure of a wastewater collection system organization. The factors discussed in this section are important. The degree of importance of each will change from community to community due to local circumstances. Critical factors include responsibility of organization, size of wastewater collection system, and existing and potential problems.

11.11 Responsibility of Organization

All of us are aware that we must operate and maintain the wastewater collection system and provide service to our customers. In the preceding short sentence, the interpretation or meaning of the word "system" can double the size of an organization in a community as compared to a similar community with the same population and size of collection system. Most collection system organizations have a policy which is usually written and adopted by the community governing body. Unfortunately, the policy is sometimes unwritten. Usually the policy includes description of the portion of the wastewater collection system assigned to the organization for operation and maintenance. Some organizations assume responsibility only for the main collection lines and laterals in the streets or easements. Other organizations may be responsible for building service lines from the street or easement laterals to the property line. Some organizations assume responsibility a short distance (three to six feet) past the property line in order to take care of appurtenances such as clean outs, overflow valves and backflow preventers. Total responsibility for the collection system up to the building is assumed by some organizations.

Let's study the advantages and disadvantages to wastewater collection system organizations created by the interpretation of the word "system." Agencies A, B, and C in the following paragraphs all will have different limits on their systems.

Agency A. Responsible for laterals and larger lines only.

Advantages:

1. Standardization of equipment and crew size is easier because lines cleaned are six inches or larger.

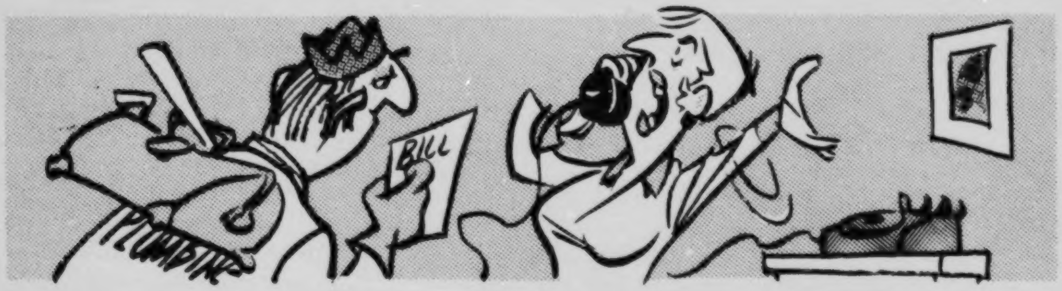
2. Access to wastewater collection system is usually more convenient.

3. Service requests or complaint calls should be minimized. Agency can handle all calls such as main line stoppages with mechanized equipment like power rodders or high velocity cleaners.

4. Public relation problems or insurance claims for flooded homes or other damage to private property are fewer in this type of organization.

5. Personnel requirements and equipment needs are less critical than for other types of organizations with more responsibility.

Disadvantages:



1. Citizens who must pay private contractor or plumber to repair or remove stoppage from building service line often believe agency should do job.
2. Street maintenance work is complicated because of random nature of repair work by private contractors and plumbers.
3. Private contractors and plumbers are allowed to make taps for old or new service connections. Often a tap is improperly installed or results in a broken lateral or main that is not reported or detected until next TV inspection or a problem develops.
4. Loss of some control over workmanship and materials may result in higher inflow and infiltration and also poor trench compaction which can cause the loss of the paved surface over the trench.

Agencies B and C. Agency B is responsible for that portion of the collection system that includes service lines to the property line or to points just past the property line. C is responsible for the entire collection system, including four-inch building service lines to the foundation of buildings. Many agencies that must maintain building service lines require a minimum size sewer of 6 inches.

Advantage:

1. Control over major portion of collection system regarding inspection of workmanship, materials and procedures used.

Disadvantages (or additional work load):

1. Increase in system size (length) by 30 to 60 percent. Usually all of the additional pipe is 4 inches in diameter and consists of many more joints and openings than the main lines of the collection system.
2. Day and night service request crews equipped with hand or small power equipment. Crews must have special equipment for working with 4-inch lines and maps with greater detail of system.
3. Access to service line portions of system often obstructed by property owners' landscaping or yard decorations.
4. System for which agency is responsible is more vulnerable to tampering and vandalism.
5. Larger number of service requests or complaints.
6. Greater public contact and higher frequency rate of flooded homes, insurance claims, and law suits.
7. Greater problem of root control due to service lines passing through planted areas.
8. Cleanouts are especially difficult to locate when covered with snow and most people don't know the location of cleanouts serving their homes.
9. May require a contruction crew to install new services and taps in areas prohibiting the use of trenching equipment.
10. Leaks may develop in sewers due to the settling of walls or buildings near the sewers.

11. Larger organization of both field workers, office personnel and engineering staff required to handle work load and maintain adequate records.

In summary, the extent of the collection system and responsibility assigned to an organization are significant factors in determining the size and type of organization needed to do the proper job.

QUESTIONS

11.1A List three critical factors that must be studied when developing the size and structure of a collection system organization.

11.1B What different levels of responsibility could be assigned to collection system organizations regarding the extent of the system serviced?

11.1C Compare the advantages of Agency A with those of Agencies B and C.

11.12 Size of the Collection System Organization

Key factors that influence the size of a collection system organization include the size of the community and area served, topography, population, industrial activity, construction practices, soil conditions, type of materials, age of facilities, adequacy of construction inspection, enforcement of sewer-use ordinances, and effectiveness of past maintenance programs. Sizes of communities may vary from a very small community of less than 1000 persons to a small community with ten to twenty miles of sewers serving an area of nine square miles of relatively flat land. Total population consists of 20,000 people with an additional industrial hydraulic population equivalent[1] of 10,000 persons. On the other extreme is a city or county agency serving the needs of areas of high population density, downtown commercial area, suburban areas with spread-out single family residences, industrial areas with significant flow volumes and seasonal peak loads, and agricultural areas with low flow contributions of wastewater to the system. The system may consist of only 1500 miles of pipe, but cover an area of 1,600 square miles consisting of flat areas, valley and river basins, and rolling hills. Also, an agency may serve a large metropolitan area containing several million people with a collection system of 6000 or more miles of pipe.

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[1] Hydraulic population equivalent. A flow of 100 gallons per day is the hydraulic or flow equivalent to the contribution or flow from one person.

The complete collection system crew for the small town may consist of only three persons on a part-time assignment basis, whereas the metropolitan collection system may have 600 full-time collection system workers. These workers may be assigned to service districts or to divisions or sections within the agency that consist of specialized crews that only perform certain critical maintenance functions.

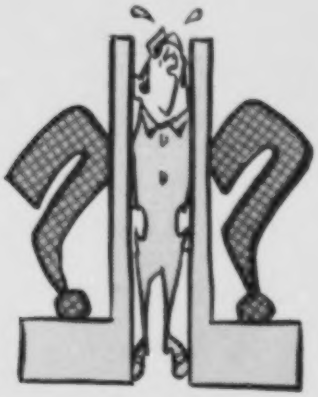
11.13 Other Responsibilities Affecting Organization

Duties assigned to wastewater collection system organizations vary from community to community. Responsibilities may or may not include the operation and maintenance of wastewater and/or storm water lift stations. How many lift stations are in the system, where they are located with regard to crew travel time, what is the maximum length of downtime each station is allowed before overflow, stand-by power facilities, odor control techniques (chlorine, hydrogen peroxide, oxygen or some other chemical), and the type and extent of telemetering system are all important considerations, also whether or not the collection system has siphons, "U" tubes, or flow regulator stations and the maintenance requirements of these facilities influence crew size and structure of agency. Some of these facilities may require staff to be permanently assigned to tend to their operation and maintenance. In many communities the wastewater collection system operation and maintenance organization also is responsible for the storm water drainage system. Sometimes this type of organization is desirable because it is a combined system, and sometimes because it is a similar system even though the storm waters are collected separately from the wastewater collection system. In some very small communities, the same crew may operate and maintain both the water and wastewater systems and treatment plants.

QUESTIONS

11.1D What factors related to size of community influence the size and structure of the collection system organization?

11.1E What features of a collection system other than the collection lines influence size and structure of a collection system organization?



11.14 System Problems

Most wastewater collection systems have problem areas. Problems may stem from an older part of the system, industrial flows, steep lines on mountains or hills, poor subsoils, high ground water tables, flat grades, or deep lines. Where are the known problem areas in your system? Try to list them, for examples:

1. Section of old, deteriorated pipe.
2. Roots.
3. Inflow, infiltration and/or exfiltration.
4. Grease.
5. Grit and debris.
6. Odors.
7. Sewer line dips or sag areas.

These types of problems plus the frequency and nature of service requests or complaint calls help to determine the type and frequency of preventive maintenance programs developed for the problem areas to maintain the desired service of the system.

To try to prevent the development of problem areas and to develop the proper size and structure for your organization, attempt to answer the following questions:

1. What is required in the system to maintain its condition and provide the longest system life possible?

2. What preventive maintenance cleaning programs are most effective in your system and what frequency of scheduling is required - every year, two years, three years, or five years?

3. Is the existing preventive maintenance program adequately reducing complaints, minimizing mainline stoppages, and keeping the system operational?

4. Could the existing program be over scheduled and performing above what is required and costing the taxpayer more than it should for essential services?

5. Who is responsible for monitoring and enforcing the sewer-use ordinance? Who does the metering, sampling and inspection for sewer-use billing?

6. Who is responsible for newly constructed segments of the collection system? Who reviews construction plans and specifications, conducts construction inspection, and does the final testing and inspection before acceptance of the new portion of the system?

7. Who performs major repairs?

8. What does your organization require for supervision and administration services? Who maintains the time cards, files records and reports, updates maps, answers the telephone, dispatches service crews, coordinates dig ups with other utility agencies such as gas, water, electric, and telephone?

9. Has a repair crew ever cut a 250 pair telephone cable or damaged a high or low pressure fuel transmission pipeline?

10. Who writes the letters, talks to the attorneys, and prepares the claim vouchers for the bills to be paid and keeps the auditors happy?

11. Who prepares and schedules the operation and maintenance program, prepares and fights for the budget to accomplish the objectives that fulfill the responsibility of the organization?

12. How much time is required to train workers in using tools, equipment, and safety gear to perform a work assignment correctly and safely? Does the agency have a training officer? Are provisions made to hire specialists to present training and safety programs? Are travel funds available to send key workers to training sessions to stay abreast with new methods, materials, equipment, and safety practices to keep the organization a safe place to work and an efficient operation?

All of the questions raised in this section must be answered. Some will be more important than others in different agencies depending on community policies, system conditions and funds available. There are other questions that may be pertinent to your agency that were not raised. For these reasons, it is not possible to propose an organization that will fulfill the needs of every community throughout the nation.

To illustrate a procedure for developing a collection system operation and maintenance organization, Section 11.2 uses a hypothetical community. You may or may not agree with the philosophy of the agency and its structure, but it is one we can all critique harshly because it does not exist.

QUESTIONS

11.1F List the typical problem areas found in many wastewater collection systems.

11.1G Could an existing preventive maintenance program over perform?

11.1H What questions should be answered regarding a sewer-use ordinance?

11.2 HOW TO DEVELOP A PROGRAM FOR CLEARWATER, USA

11.21 Description of Typical Town

Assume Clearwater (our typical town) originated in the late 1800's. The downtown area is located adjacent to a river with rolling hills on both sides. Clearwater's population and economy have fluctuated with the times. The depression of the thirties was a low period that was followed by accelerated growth during the forties, fifties, and early sixties similiar to hundreds of other communities in this country.

Today Clearwater has a population of 180,000 people and an equivalent industrial population of an additional 25,000 persons. The wastewater collection system originally was a combined storm and sanitary system; but in the mid thirties, through the Federal W.P.A. program, the system was separated and a wastewater treatment plant was constructed consisting of Imhoff tanks. Since then, urban growth of subdivisions has added additional collection systems, intercepting sewers, sixteen wastewater lift stations, and a new secondary treatment plant designed with capacity of thirty million gallons per day. The length of the total collection system is 760 miles consisting of pipe diameters ranging from 4 inches to 60 inches.

11.22 The New Superintendent

A new superintendent is hired by the Clearwater Director of the Department of Public Works. He will be responsible for field activities of the Water Reclamation Division which consists of the wastewater collection system. The wastewater treatment plant is part of the division, but has a superintendent to oversee its operation. Upon introduction to the new position, the collection system superintendent is given the following information:

1. Clearwater assumes responsibility of the wastewater collection system to five feet past the property line.

2. Overflows, spills, or raw wastewater by-passes must be reported to the following:

    a. Regional Water Pollution Control Agency
    b. Local Health Department
    c. Director of Public Works

3. Supplies and equipment must be obtained through the Clearwater City purchasing department.

4. Personnel management practices must be in accordance with rules prescribed by the Clearwater Personnel Department.

5. Sewer-use ordinance enforcement and billing will be part of the section's function, with support from the wastewater treatment plant for required laboratory analysis to determine use fees for industrial and commercial discharges to the collection system. This program is new and has not been implemented.

6. All funding for section activities must be budgeted.

7. Superintendent is responsible for planning and implementing maintenance, operation, training, and safety aspects of his section.

8. Department of Public Works' staff engineers provide support for design work or technical engineering when required. Work requests must be in writing on department work request forms.

As the new Superintendent is leaving his orientation meeting, the Director of Public Works informs him that he has arrived just in time to prepare the next fiscal year's budget, and he wants to see it in six weeks.

11.23 The Existing Organization

For simplicity and brevity to prevent this chapter from becoming a book by itself, let's assume the present organization is functioning and doing a fairly reasonable job, but the crews appear to be spending most of their time responding to emergencies and surviving on a day-to-day program. Some records such as maps are excellent, but other records do not contain all of the necessary information to describe the condition of the system and the causes of problems. The crews are responding to an average of three main line stoppages a day plus an additional 18 service requests from the public with sewer problems. The performance of the organization was below the standards desired by the new superintendent in terms of the current annual number of stoppages and odor complaints.

The previous superintendent had more or less grown up with the system, being transferred from the Division of Streets in the late forties. He was not convinced that some of the newer equipment, such as closed circuit television cameras, was worth the cost so he never bothered to investigate the results that could be achieved by properly using the equipment. Two power rodders and a high velocity cleaner were purchased because the superintendent for another community said they were really great and everybody was using them. Radios were installed in the trucks and the crews could reach any point in the collection system in an hour. Apparently the agency thought it was doing just as well as other collection system agencies thought they were doing.

QUESTIONS

11.2A Overflows, spills, or raw wastewater by-passes must be reported to whom by the Clearwater Superintendent?

11.2B What are the responsibilities of Clearwater's Superintendent?

11.24 Organizing a Wastewater Collection System Operation and Maintenance Organization

The new Superintendent spent many hours reviewing records, maps, crew activities at various work sites, and held lengthy discussions with his supervisor. The Superintendent reviewed Chapter 5, Pipeline Cleaning and Maintenance Methods, and Chapter 10, Section 10.3, Records. Next he prepared the following brief outline or summary of the wastewater collection system.

A. The collection system

1. 760 miles total length. Estimated lengths:

   a. 311 miles of 4-inch building service lines

   b. 167 miles of 6-inch sewers

   c. 80 miles of 8-inch sewers

   d. 48 miles of 10-inch sewers

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   e. 17 miles of 12-inch sewers

   f. 154 miles of intercepting sewers ranging from 15 to 60 inches in diameter.

   g. Number of manholes unknown

2. Wastewater lift stations

   a. Number of stations, 16

   b. All stations telemetered with failure alarms. Cause of failure is not indicated - only that station is in trouble. Police Department switch board monitors lift station alarm system during off-duty hours and weekends.

3. Condition of system

   a. Unknown - need to TV system

4. Known problem areas in system

   a. Infiltration/inflow during storms in older portion of town.

   b. Power rodding reports indicate significant root problem in northwest suburban area.

   c. High velocity cleaner reports indicate excessive grease build ups in area with restaurants on Elm Street down to 30-inch intercepting sewer at 36th Street.

   d. Treatment plant superintendent reports high volume of grit removal at treatment plant, especially during storms. Also, he reports heavy solids and organic loading at random times and that he suspects the source is the XX industrial plant.

  - e. No enforcement of sewer-use ordinance or initiation of sewer-use billing fee.
  - f. Lift stations are in poor appearance and housekeeping needs improvement.
  - g. Main line stoppages are averaging three per day.
  - h. Service request calls are averaging 18 per day (mostly odor and stoppage complaints).

B. Needs (Equipment and staffing to handle)

1. Emergency calls.
   - a. Main line stoppages
   - b. Service requests
   - c. Lift station failures
   - d. Flooding from stoppages

2. Preventive Maintenance
   - a. Collection system
     - 1) TV system
     - 2) Power rodder use
     - 3) High velocity cleaner use
     - 4) Balling (rear easements and streets)
     - 5) Bucket machine, scooter, kite and parachute use
     - 6) Root control program
     - 7) Crew training to use equipment properly and safely

b. Lift stations

1) Develop new preventive maintenance program

2) Review overhaul schedule

3. Corrective maintenance program to repair lines

a. Service lines

1) Develop policy for service crews

2) All service line dig ups will have cleanouts installed

3) Increase smoke testing program to reduce illegal inflow and improper connections

4) Establish priority list for repairs as reports from TV inspection of system are received

5) Persuade Personnel Department to permit increase in repair crews during summer months to reduce backlog of repair work.

b. Main lines

Items 3, 4, and 5 above under a. Service lines

4. New construction

a. New services

1) Stop plumbers from making taps into main lines. All future taps will be made by Clearwater main line maintenance and repair crews only.

2) All street or easement work will be done by Clearwater crews. Street patching will be coordinated with superintendent of streets.

        3) Teach crews to use boring rig and reduce sidewalk repairs.

        4) All new commercial and industrial services installed by Clearwater crews will be paid for by customer on basis of supervisor's field estimate of installation costs, including metering and sample vaults.

    b. New lines

        1) Any segment of a new line over 100 feet long or over 20 feet deep will be installed by a private contractor.

        2) Review all prints.

        3) Be sure all contractors use safe procedures.

        4) Record pertinent field information on "as-built" plans.

        5) Establish policy of TV inspecting all new lines before acceptance by City of Clearwater.

        6) Investigate feasibility of renting backhoes, trucks and trailers instead of purchasing equipment.

        7) Develop a shoring school for repair and new construction crews.

5. Office management

    a. Update record system

    b. Develop maintenance program for collection system

    c. Review records and programs for cost effectiveness.

C. Objectives

Minimize the number of

1. Stoppages per mile of sewer
2. Service requests (complaints)
3. Failure per lift station

11.25 Organization and Function of Agency

Having reviewed policy, responsibilities, objectives, and the existing collection system and its needs, the Superintendent is now ready to develop an agency capable of meeting its responsibilities. Organization charts are helpful to show the structure and chain of command of an agency. Table 11.1 shows the organization of Clearwater's City Administration down to the level of the Superintendent. Also shown are the major units under the supervision of the Superintendent. The following sections describe the function and structure of each unit within the Superintendent's agency.

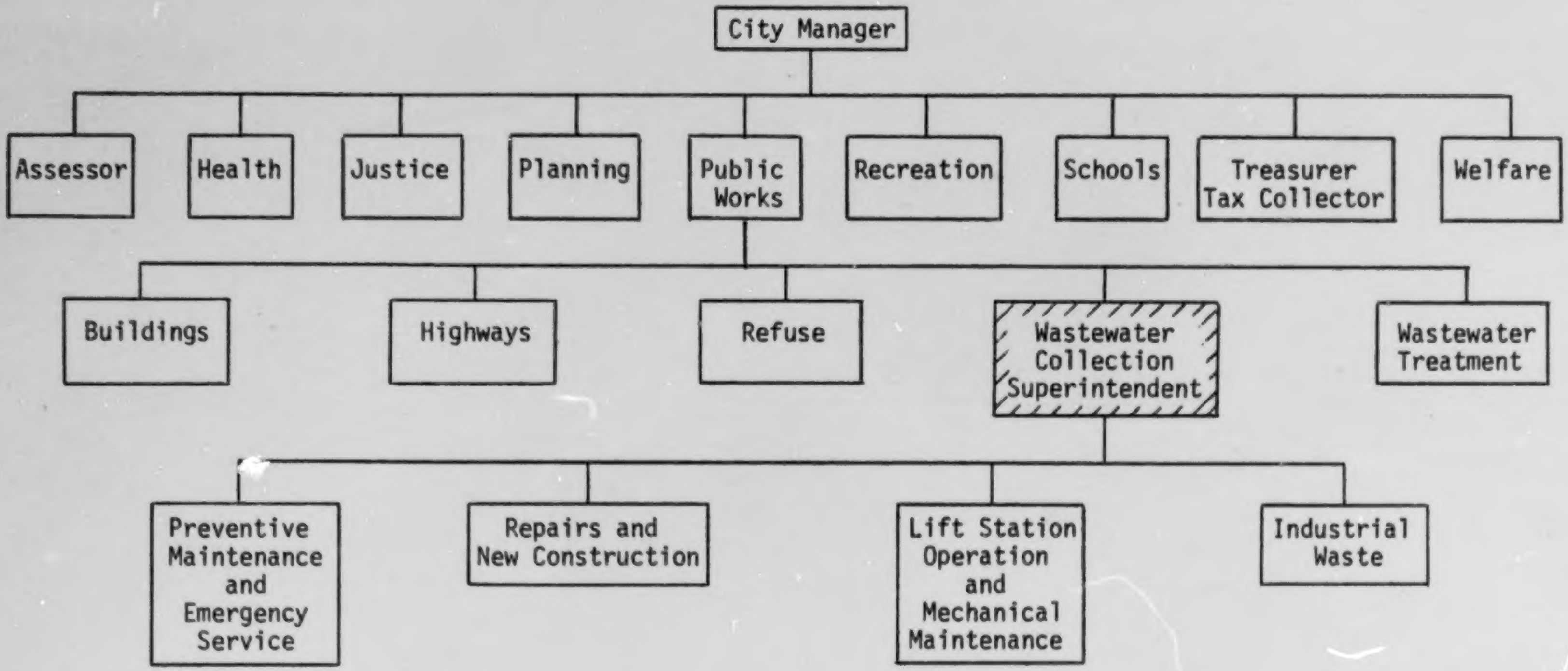
QUESTIONS

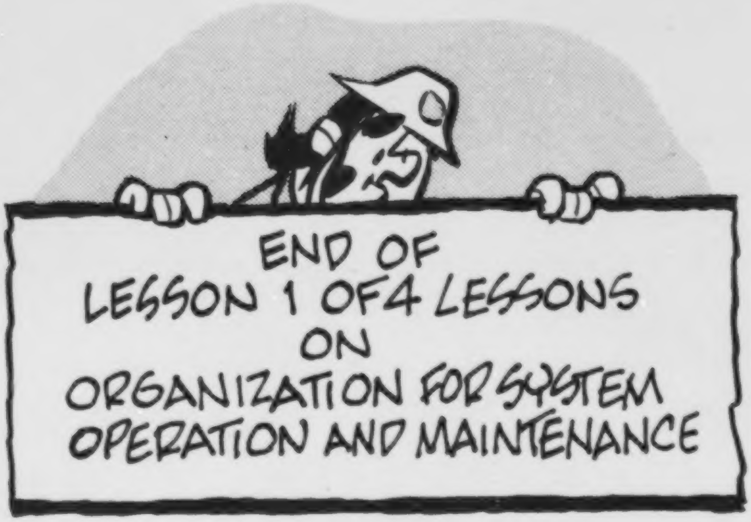
11.2C What items would you consider if you summarized a wastewater collection system?

11.2D What items would you consider if you summarized the needs of a wastewater collection system?

11.2E What should a superintendent do before attempting to review or develop the function and structure of each unit within an agency?

TABLE 11.1. ORGANIZATION OF CLEARWATER


City Manager
Assessor
Health
Justice
Planning
Public Works
Recreation
Schools
Treasurer Tax Collector
Welfare
Buildings
Highways
Refuse
Wastewater Collection Superintendent
Wastewater Treatment
Preventive Maintenance and Emergency Service
Repairs and New Construction
Lift Station Operation and Mechanical Maintenance
Industrial Waste


END OF
LESSON 1 OF4 LESSONS
ON
ORGANIZATION FOR SYSTEM
OPERATION AND MAINTENANCE

DISCUSSION AND REVIEW QUESTIONS

Chapter 11. Organization for System Operation and Maintenance

(Lesson 1 of 4 Lessons)

At the end of each lesson in this chapter you will find some discussion and review questions that you should answer before continuing. The purpose of these questions is to indicate to you how well you understand the material in this lesson. Write the answers to these questions in your notebook before continuing.

1. What benefits result from an effectively operated and maintained wastewater collection system?
2. What factors should be considered when developing or modernizing the structure of an organization that operates and maintains a wastewater collection system?
3. How do the total length of sewers serviced, population, industry, type of problems, and topography influence the type of organization that operates and maintains the collection system?
4. Why should a Superintendent prepare an inventory of the collection system, identify the system needs, and outline the objectives before attempting to develop or review an organizational structure to operate and maintain the collection system?

CHAPTER 11. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 2 of 4 Lessons)

11.3 EMERGENCY SERVICE

The first priority of a wastewater collection system agency should be to have the ability to handle emergency service requests quickly and efficiently. Emergency service requests usually consist of calls to remove collection line stoppages and causes of flooding and to correct lift station failures.

11.31 Stoppages or Blockages

Quickly clearing stoppages before major flooding and damage occur is a major concern. Sewer line stoppages can develop when an obstruction causes debris to build up and slow down the flow of wastewater, gradually forming a block or halt in the flowing wastewater.

11.311 Types of Stoppages

For the sake of recording stoppages for follow-up maintenance work, stoppages must be identified according to the cause or type of problem. Stoppages are caused by obstructions such as roots, grease, debris, broken pipe or a joint failure. These obstructions may require removal, repair, or replacement immediately to correct the problem. See Chapter 5, Section 5.121, Types of Stoppages, for a discussion of the causes of various types of stoppages.

11.312 Location of Stoppages

Most emergency calls are related to stoppages and these will be classified in two categories:

1. Main line
2. Building service line

A main line stoppage is a major problem and can affect many customers on that portion of collection system. The main line stoppage is usually discovered by a private citizen who telephones into the office that a manhole is overflowing.

The building service line stoppage usually affects only the home or business that is backed up (unless a double wye is used at the property line[2] and someone else's wastewater backs up), and the home resident telephones in when their sinks or toilet facilities will not drain.

In either of the above cases, the office personnel receiving the call should record the following information in a permanent log:

1. Date
2. Time call was received
3. Name of person calling
4. Phone number of person calling
5. Mailing address or street address where problem is occurring. (Address also is important for billing purposes if agency serves more than one sewer assessment district)
6. Type of problem they are reporting.

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[2] This situation usually occurs when one service line is provided at the property line between two lots. Justification for such practice, in most cases, is for economical purposes to the benefit of the land developer. Such service lines are commonly referred to as "dual service" lines. These lines often result in problems regarding who is responsible for the maintenance of the sewer. When a stoppage occurs in the dual service line in the easement, who is responsible? Is the property owner or the maintenance agency supposed to clear the stoppage?

The dispatcher will have the following priority list:

1. Manhole overflowing (main line stoppage)
2. Flooded home or business (main line or service line stoppage)
3. Manhole cover off (liability risk)
4. Cleanout overflowing (nuisance and health hazard)
5. Home service backed up.

The dispatcher radios the field supervisor (foreman)[3] of the unit and provides the address or location and nature of the problem. Also, the dispatcher will be responsible for:

1. Recording the time the call was dispatched to the service crew supervisor.
2. Recording the time the service crew or their supervisor reports the correction of the problem.

When multiple emergency calls are received at the same time, the service crew will respond to the highest priority call and the field supervisor to the other calls. The field supervisor evaluates the problems, assigns priorities, redirects service crews, and requests assistance from field preventive maintenance crews for specific equipment or assistance in handling calls as necessary.

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[3] Recommended standard job titles are presented in parenthese ( ) in this chapter after the descriptive job titles. The standard job titles are from Manpower Requirements for Wastewater Collection Systems in Cities and Towns by Elie Namour for Manpower Development Staff, Office of Water Program Operations U.S. Environmental Protection Agency, Washington, D.C., June 1973.

The office clerical and dispatch staff are responsible for records, reports and accuracy of the initial phase of service requisitions.

QUESTIONS

11.3A List the priority responses to requests for emergency services.

11.3B What does the field supervisor do when multiple emergency calls are received?

11.32 Flooding Caused by Stoppages

One of the most delicate problems of public relations which Clearwater or any other agency must face is the occasional flooding of a home, a business, or a street area caused by a stoppage and the resulting back up of wastewater. Despite the risk of incurring increased liability, either your insurance carrier, a janitorial or sanitation clean-up service, or an agency crew should be sent to the property to assist in cleaning and removing articles which may have been damaged or will be damaged if left in place. These crews should be the first line of defense and be alerted when the possibility of flooding occurs. Response calls must be prompt. Dispatchers handling such calls may be able to give instructions to the home owner which will avoid damage from impending flows.

Above all, you and your fellow workers must follow policies which have been approved by your agency's legal department because flooding often leads to law suits. When possible, a radio dispatched crew should be sent to investigate any irregularity in the functioning of the house sanitary sewer system. In this manner there will be an opportunity to locate the trouble and see that it is positively not the city's or agency's responsibility which has caused the back up damage. Disputes often arise regarding whether stoppages occurred on or off private property. Problems can be avoided by thoroughly investigating the cause and location of the problem whenever a stoppage is cleared.

In the case where flooding has occurred due to a stoppage in a main sewer line and the city or agency is responsible, the crew should follow set procedures for unplugging the stoppage and then helping with the clean up of the house. Always advise your legal department of what has happened and exactly what you did as soon as possible. In many cases an out-of-court settlement for damages incurred has been made by the legal department or insurance company, thus saving the city or agency the high court costs.

The city or agency should have clean up equipment or a sanitation service organization available to respond quickly to any location in need of clean up service. This procedure insures that a rapid clean up of wastewater from the household area will result in less water damage and many other articles can be salvaged. Prompt action can bring down the cost or expense of replacing articles only slightly damaged. A quick response of water removal also will save existing hardwood floors from warping or the floor tiles from becoming loose.

If the flooding was caused by the failure of a pump that was supposed to discharge the waste from the basement of a home or business, the community policy must clearly define who is responsible for the operation and maintenance of the pump. If the flooding is caused by a low service line in relation to the collection system and is an overflow point, then a backflow preventer and an overflow valve should be installed to prevent future flooding. Agency policy must clearly state who is responsible for maintaining the facilities. Many health departments dislike overflow valves; but if they were given the choice of either flooding their family room carpet with wastewater or the front lawn, I am sure they would prefer the lawn.

11.33 Other Requests

Service request crews frequently receive calls which consist of water leaks from domestic water supply systems which should be referred to the water department. Requests for recovering valuable items such as diamond rings, jewelry, money, false teeth, and keys that have been lost down the drain or flushed down the toilet by a small child or absent minded adult must be handled according to agency policy. If attempts are made to recover these items, the work should be assigned to a preventive maintenance crew to ball the portion of the line serving the residence. Very often these items are recovered and greatly enchance the public's image of the agency. Responding to these requests ts time consuming and expensive.

A policy must be established for handling these requests if the frequency exceeds one per month. Included in the policy should be a disclaimer for recovery of lost items. The only chance of finding them would be in some trap or constriction that serves as a trap for heavy objects.

QUESTIONS

11.3C What should be done when a private home becomes flooded with wastewater?

11.3D How can legal problems resulting from flooding be minimized?

11.3E How can flooding problems caused by a low service line in relation to the collection system be corrected?

11.3F Who should handle service requests to have valuable property recovered from a sewer?

11.34 Emergency Service Crew Supervisor

The field supervisor (Foreman) should respond immediately to emergencies and investigate all service requests or complaints. This investigation determines which calls have the higher priority for order of assignment to the emergency crew. In some cases, the problem is discovered to be past the point of five feet inside the property line. This is not Clearwater's problem. The field supervisor should explain Clearwater's policy and responsibilities, and direct the home or business owner to a solution by private enterprise.

This procedure may not get the emergency crews to the problem area as fast as possible, but its advantages include:

1. On-the-spot evaluation of the problem by a supervisor.
2. Selection of a solution and procedure to solve the problem by an experienced supervisor.
3. Contact with the public by an experienced supervisor who is responsible for decision making and policy enforcement.
4. Keeps the supervisor in contact with the crews and informed of their location and what they are doing.

QUESTIONS

11.3G Who should investigate all service requests or complaints?

11.3H What is a limitation of having a field supervisor investigate all emergencies?

11.3I What are some advantages of having a field supervisor investigate emergencies?

11.35 Emergency Service Crew

The emergency service crew's job is to respond immediately and correct the faulty condition. A statement of the cause of the problem, the solution, and any recommended additional work must be accurately recorded. When emergency crews have slack time (no emergency service calls), they should be assigned work that can quickly be left when an emergency occurs.

Typical work includes collecting and verifying essential information needed by the agency such as:

1. Map verification. Determine exact location of facilities such as manholes, cleanouts, flusher branches, and rodding inlets.

2. Services connected. Use dye tests to verify who is and who isn't connected to collection system.

3. Condition of collection system.

    a. Manholes. Inspect covers and barrel condition and sniff for odors. See Chapter 4, Section 4.3, Inspection of Manholes.

    b. Flow rate through collection system.

    c. Locate manhole that may be below grade as a result of streets being resurfaced. These manholes should be raised to grade.

11.351 Manpower

Emergency crews should consist of two workers.[4] If a crew member is required to enter a manhole, the field supervisor or someone else available must be called to assist the crew. With a two-worker crew, one worker could enter the manhole if an approved tripod with a pulley and harness is available and the topside person is adequately trained in the use of this equipment. Approval of tripod or other equipment must be obtained by the appropriate authorities in advance.

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[4] Manpower. One Maintenance Man II and one Maintenance Man I.

11.352 Equipment (Fig. 11.1)

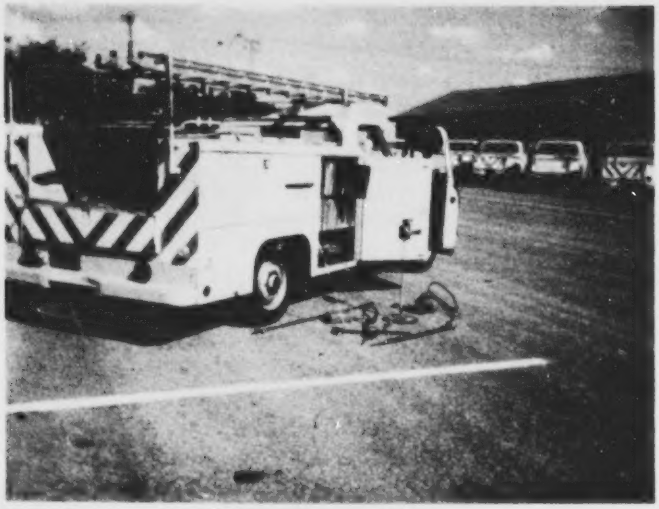

Fig. 11.1. Emergency service crew rod truck.

1. Vehicle. Preferably a 3/4 or 1-ton truck with a utility body. Desirable equipment on the truck is described below.

2. Radio with field call. The field call provides a means for the dispatcher to summon the crew to the unit's radio when they are working away from the truck by blowing the vehicle's horn and turning on the rotating beacon if it is not in use. Some agencies place a speaker on the outside of a vehicle. If this type of equipment is not available or too expensive, use a "page boy." This equipment enables the dispatcher to start a buzzer which signals the worker in the field to phone the dispatcher.

3. A complete set of maps of the collection system. If a complete set becomes too bulky, maps may be placed on microfilm and observed by using a viewer.

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4. Field report forms as required.

5. Sewer rods, reel, and various sizes of augers.

6. A small portable power rodding unit is very helpful for use as an aid in turning the sewer rods in difficult line stoppages.

7. Toxic gases, explosive conditions and oxygen deficiency detection equipment.

8. Small air blowers for ventilation.

9. Portable generator for lights and tools.

10. Ladder for descending into manholes.

11. Safety harness and ropes.

12. Poles with hooks for dislodging and removing obstructions found in a manhole.

13. First aid kit.

14. Waterless hand soap and rags.

15. Buckets and rope hooks.

16. Other basic items include small tools, rubber boots, gloves, hard hats, shovels, locators, probes, cover boards, barricades, and traffic safety cones and warning signs.

All of this equipment should be in the vehicle for use when needed.

QUESTIONS

11.3J What can an emergency crew do when there are no emergencies?

11.3K How many workers are on an emergency service crew?

11.36 Service Crew Functions for Corrective Action

11.361 Enroute to Problem Area

Upon receipt of assignment from dispatcher or field supervisor, the crew performs the following tasks en route to problem:

1. Begins to fill out service request form:
    a. Time call received
    b. Street address of problem
    c. Unit number and names of crew members
    d. Retrieve map of problem area from vehicle map storage file
2. Notifies dispatcher upon arrival at problem area of time of arrival and location of unit. If supervisor or crew cannot locate problem, dispatcher is requested to verify service request or complaint with party who submitted original call.

11.362 Main Line Stoppage

On a main line stoppage (manhole overflowing), the field supervisor examines the maps to determine direction of flow. The downstream manhole is inspected and observed for no flow or if the flow is restricted or reduced through the manhole or backed up into the manhole. When the manhole with reduced flow or no flow is located, the stoppage is located between this manhole and the upstream manhole. First the field supervisor tries to unplug the sewer by using a plunger-type tool[5] connected to sections of half-inch pipe. By probing the invert of the upstream manhole with the plunger and creating a stirring or mixing motion, the stoppage may be cleared. If this fails, a service crew is directed to the lower manhole and starts to work upstream to clear the blockage.

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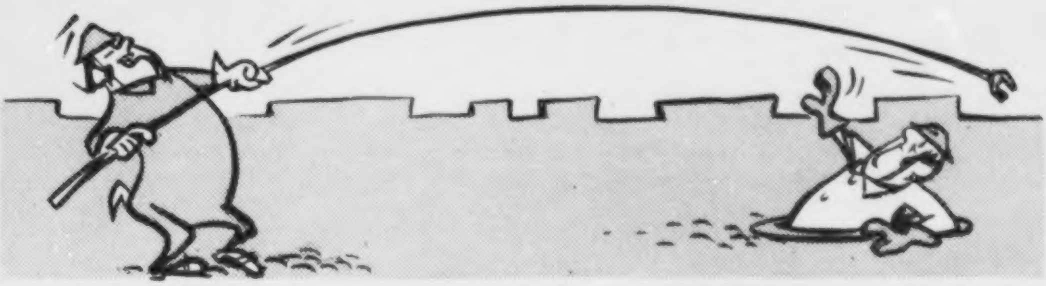
[5] Plunger consists of two rubber disks attached to a length of half-inch iron pipe.

11.363 Stoppage Removal

Hand Tools. Some basic hand tools used to remove or dislodge a stoppage in a sewer are somewhat simple in nature. Such tools as a wooden pole or an aluminum pole equipped with a hook, a plunger type tool, a clamp tool, a rope or cable sling and flexible steel sectional hand rods with auger attachments are examples of a few useful tools.



The poles have been very effective to remove or dislodge materials causing a stoppage in the flow through a manhole. The clamp tool (also called a hand clamp) is a piece of equipment which is spring loaded and can remove almost any material its jaws can grab hold of from inside a manhole. A rope or cable sling can be lowered into a manhole and positioned around a protruding object of a large nature. The pole tool snags and removes objects causing the stoppage.

All of the above tools are used when working from the ground surface area. Flexible steel sectional hand rods and their auger attachments can be considered the real workhorse of the basic hand tools mentioned. The maintenance worker must have a good strong back and a lot of good imagination to minimize the hard work needed to operate this tool. Once this tool is in the line and working on the stoppage, one must visualize what is taking place between the auger and the obstruction blocking the line. This can be done by feel, sound, and smell; and with experience, the job becomes routine. (Example: A blind man finds his way by using his touch, hearing, smell, and memory to guide him).

There should be a set of procedures to follow in order to be consistent in the art of rodding or attacking an obstruction lodged in the barrel of the sewer. First of all, try to rod from a dry manhole whenever possible. An exception may be made when access to such a dry manhole may be impossible or when rodding to remove roots from a known root problem area. To rod a stoppage, the set up requires the rods to be inserted through a manhole guide pipe. An auger attachment of some type is connected to the end of the rod. The length of the guide pipe can be determined by placing a wooden pole down to the flow line at the bottom of the manhole and marking the distance to the street level.

The manhole guide pipe, rods and auger are placed into the upstream side of the manhole invert. The rods are pushed through this guide pipe until the obstruction is reached. To dislodge the obstruction or plug, the first procedure would be to try ramming the obstruction with the auger. In many cases, this will dislodge the obstruction and allow the built up water pressure (head pressure) upstream to force the debris to flow downstream. The manhole rod guide pipe can be used to hold back dislodged debris; and with the aid of a pole hook or clamp tool, this material can be removed, thus preventing a future stoppage from possibly developing downstream.

When the ramming procedure does not solve the problem; a turning bar must be inserted into the rod knuckle exposed at the top side of the guide pipe. The rods are turned in the clockwise direction allowing the auger to cut or worm itself into the plug. The rods and auger should be pulled back after a few turns, allowing the auger to pull away part of the debris. This procedure should be repeated until the plug or blockage is removed. In some cases where the auger is turned repeatedly, it becomes ineffective due to the auger's becoming packed with debris. In this case, the rods should be turned in the counter-clockwise direction to unscrew the material from the auger coil. Try again, thus giving the auger another chance to cut and bite into the plug.

In the more difficult stoppages where hand rods are used, it is necessary to use a small portable gas-powered rodder machine as an aid in cutting through the obstruction. The use of a power assist on hand rods could be extremely dangerous and caution should be used. The development of excess tension (torsional stress) on the rod could cause them to break at the ground level and cause a whip action which could harm or injure a workman or someone close by.

If the line cannot be opened by the service crew, they notify the supervisor who dispatches power equipment such as a high velocity cleaner or a power rodder to try to open the line.

11.364 Service Line Stoppage

When a service line stoppage occurs, the first job the crew does upon arrival is to inspect the main line. Inspection of the upstream and downstream manholes on the main line will verify if the main line is open and flowing. If the main line is not flowing or if it is surcharged, the crew inspects the main line until the area of the stoppage is located and cleared.

If the main line is clear and flowing, the crew proceeds to the complaint address. The service line cleanout is inspected to determine if the portion of the service line from the property line to the main line is open and clear. This determination is achieved by removing the cleanout cover and running a hand rod with a 2 or 3 1/2-inch auger down the cleanout to the main line. Make sure that sufficient rod is used to reach the main line according to the distance shown on the map and your field estimate of the distance. Sometimes service lines can be cleared using a plunger-type tool. By placing the plunger at the bottom of the cleanout and yanking upwards, the suction pressure created may clear the stoppage. If a cleanout is not available, the crew or supervisor (after inspecting the main line) must inform the resident that it is not Clearwater's problem and that they should call a plumber.

If a plumber inspects the building service line and finds the line is open from the house to the property line and the service line is still plugged, then a service crew returns to the problem area. The crew digs up the service line between the property line and the building, but staying within the five-foot limiting distance. When the crew uncovers the service line, the line is cut into, rodded, and the blockage cleared in the street or easement area to the main line, and service is restored. Cover boards three-quarter inch thick and 4 feet by 4 feet are placed over the excavation to prevent people or animals from falling into the excavation. A barricade is placed on the cover board over the excavation to warn people of the excavation until the problem is repaired and the excavation is filled.

11.365 Completion of Forms

When the job is finished, the service request form is completed. (Figures 6.7 and 6.28) Essential information includes:

1. Cause of problem - roots, rags, grease
2. Time job completed
3. Man-hours required

The crew also fills out a repair request card giving the following information:

1. Nature of repair (install cleanout at property line)
2. Address of repair
3. Map location
4. Size of service line and material of line
5. Depth of service line
6. Date requested
7. On the back side of the card, draw a map showing the property serviced, distance to street or easement, major buildings or identifying marks to determine location of new cleanout (Fig. 6.35).

Persons living at the residence are informed that service is restored and the dispatcher is notified that the crew is available for another assignment.

The corrective maintenance repair unit will install the new cleanout, fill in the excavation, and restore landscaping to previous condition. After the job is completed, a letter and questionnaire are sent to the resident asking for comments regarding the handling of the problem (see Chapter 10, Section 10.224, Report of a Complaint). The next time a service request is made to this address, the cleanout will permit the supervisor or service crew to rod from the new cleanout to the main line. The problem can be removed or the resident can be informed that it is their problem and that they must hire a plumber to clear the service line from the building to the property line.

QUESTIONS

11.3L What does an emergency service crew do enroute to a problem area?

11.3M How is the location of a main line stoppage determined?

11.3N How are stoppages removed?

11.3O What is the first job the crew does upon arrival to clear a service line stoppage?

11.3P How is a service line stoppage cleared?

11.3Q What forms should be completed after clearing a service line that required the line to be dug up?

11.3R Which crew should install a new cleanout if one is required?

11.37 Emergency Service Crew Staffing Requirements

Clearwater's Water Reclamation Superintendent believes that through his review of the existing situation and the preceding guidelines, the emergency service request unit should be organized, staffed and equipped as shown in Table 11.2. Tables showing staffing requirements contain a descriptive job title in the table and the recommended or standard job title[6] footnoted at the bottom.

For nights off, weekends, and holidays, the following method will be used to meet staffing needs. Division workers will be scheduled in advance to be on call for one week periods, with the week beginning on Friday afternoon. The Police Department dispatcher will notify crews by telephone of emergency calls.

On Call Staff

1	Collection system supervisor (foreman). Analyzes all off duty service requests or complaints before dispatching crew. This procedure can reduce overtime paid crews.
1	Collection system repairman (crew leader - Maintenance Man II)
1	Assistant collection system repairman (Maintenance Man I)

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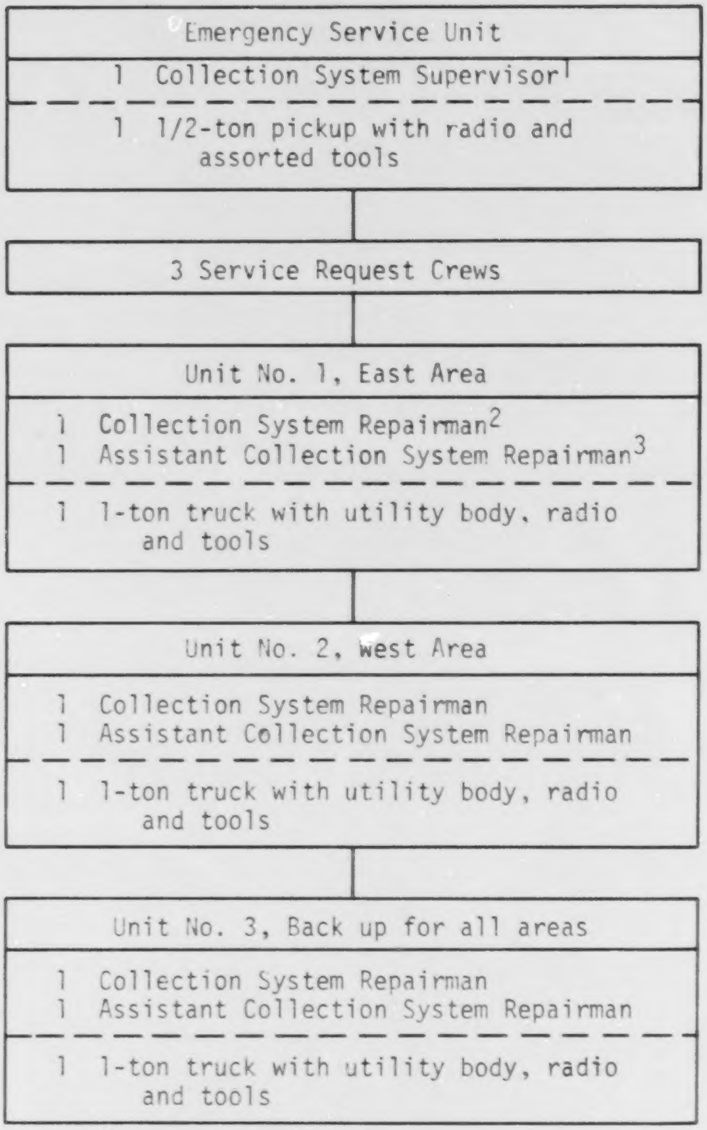
[6] Namour, Elie, Manpower Requirements for Wastewater Collection Systems in Cities and Towns, Manpower Development Staff, Office of Water Program Operations, U.S. Environmental Protection Agency, Washington, D.C., June 1973.

TABLE 11.2. EMERGENCY SERVICE REQUEST UNIT ORGANIZATION, STAFFING AND EQUIPMENT



Emergency Service Unit

1 Collection System Supervisor[1]

1 1/2-ton pickup with radio and assorted tools

3 Service Request Crews

Unit No. 1, East Area

1 Collection System Repairman[2]
1 Assistant Collection System Repairman[3]

1 1-ton truck with utility body, radio and tools

Unit No. 2, West Area

1 Collection System Repairman
1 Assistant Collection System Repairman

1 1-ton truck with utility body, radio and tools

Unit No. 3, Back up for all areas

1 Collection System Repairman
1 Assistant Collection System Repairman

1 1-ton truck with utility body, radio and tools

1. Foreman

2. Maintenance Man II

3. Maintenance Man I

NOTE: All three collection system repairmen report directly to the collection system supervisor.

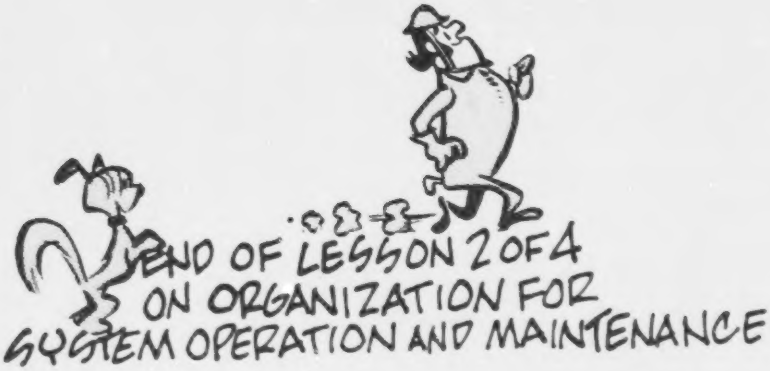
Any of the service request trucks may be used. For record keeping and radio dispatching purposes during off duty hours, this unit will always be designated as UNIT NUMBER 4. The unit number 4 designation simplifies the work of a radio dispatcher unfamiliar with the emergency units and identifies pertinent records as a service handled during off duty hours.

NOTE. Lift station failures will be discussed in Section 11.6, Mechanical Maintenance and Lift Station Operation.

QUESTIONS

11.3S How many emergency service request crews does the superintendent believe necessary?

11.3T Why was the emergency service unit given a special designation?


END OF LESSON 2 OF 4
ON ORGANIZATION FOR
SYSTEM OPERATION AND MAINTENANCE

DISCUSSION AND REVIEW QUESTIONS

Chapter 11. Organization for System Operation and Maintenance
(Lesson 2 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 1.

5. What are the activities or duties of an emergency service crew?
6. What causes stoppages or blockages?
7. How would you determine the priority of job assignments for an emergency service crew?
8. Why are public relations important when an emergency service crew responds to a stoppage that floods a home?
9. Why should a field supervisor investigate emergencies?
10. How would you remove a stoppage in a sewer?
11. What would you do after a stoppage has been removed?

WHAT·WHEN·HOW
WHERE·WHY·WHOSE·WHETH

CHAPTER 11. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

(Lesson 3 of 4 Lessons)

11.4 PREVENTIVE MAINTENANCE UNIT

11.41 Clearwater's Existing Program

A review of the past records of Clearwater's preventive maintenance unit reveals some very serious problems. The crews were on the job and working, but there had not been a significant reduction in the number of main line stoppages and service requests during the past few years. The reason for the lack of a reduction appears to stem from two sources. The condition of the system is not known and the field crews need special training on when, where and how to use the available equipment and the effectiveness of the equipment.

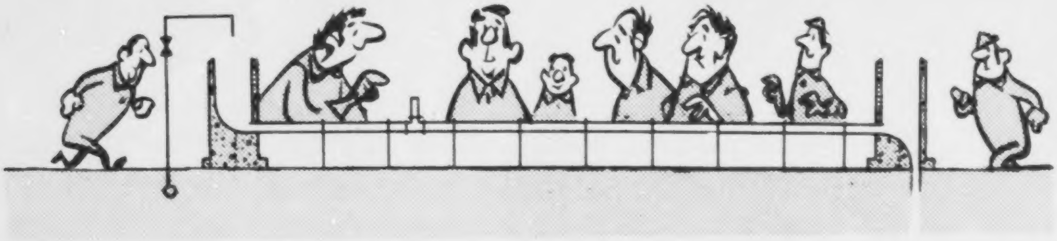
11.42 Evaluation of Condition of System

To evaluate the condition of the wastewater collection system, a closed circuit television unit can be rented to inspect preselected problem portions of the collection system throughout the city. A representative of the TV equipment supplier should spend at least one week in the field instructing the selected crew and supervisors in the use of the TV unit. Existing problems found in the collection system should be video taped for presentation to the Director of Public Works and the engineering staff to identify and/or justify correction or future programs. This video tape also should be shown to other field crews who will not have the opportunity to work with the unit during the one-month rental period. Video tapes should provide:

1. Exact location and identification of problems viewed.
2. Confirm or change the evaluation techniques used by supervisors and field crews to identify the causes of stoppages.
3. Permit supervisors to see and evaluate the effectiveness of power cleaning equipment to do the intended job under various pipeline conditions.

4. Evaluation of the usefulness of a closed circuit TV unit on a lease basis or on a part-time rental basis.

11.43 Training of Field Crews



Training of field crews can be assisted by the construction of a 6-inch clear pipe (Figs. 11.2 and 11.3) that allows the crews to observe what's happening in a line when the various types of cleaning equipment travel through it.

This training line also should be used to train all field crews in the safe and proper use of sewer cleaning equipment. Pieces of equipment that can be used to train crews with this facility include:

1. Hand rodders
2. Power rodders
3. High velocity cleaners
4. Sewer balls
5. Kites, parachutes, cones, and pigs
6. Sewer scooters
7. Bucket machines

In addition, the training facility can be used so crews can learn how to flush lines, use chemicals and install plugs.

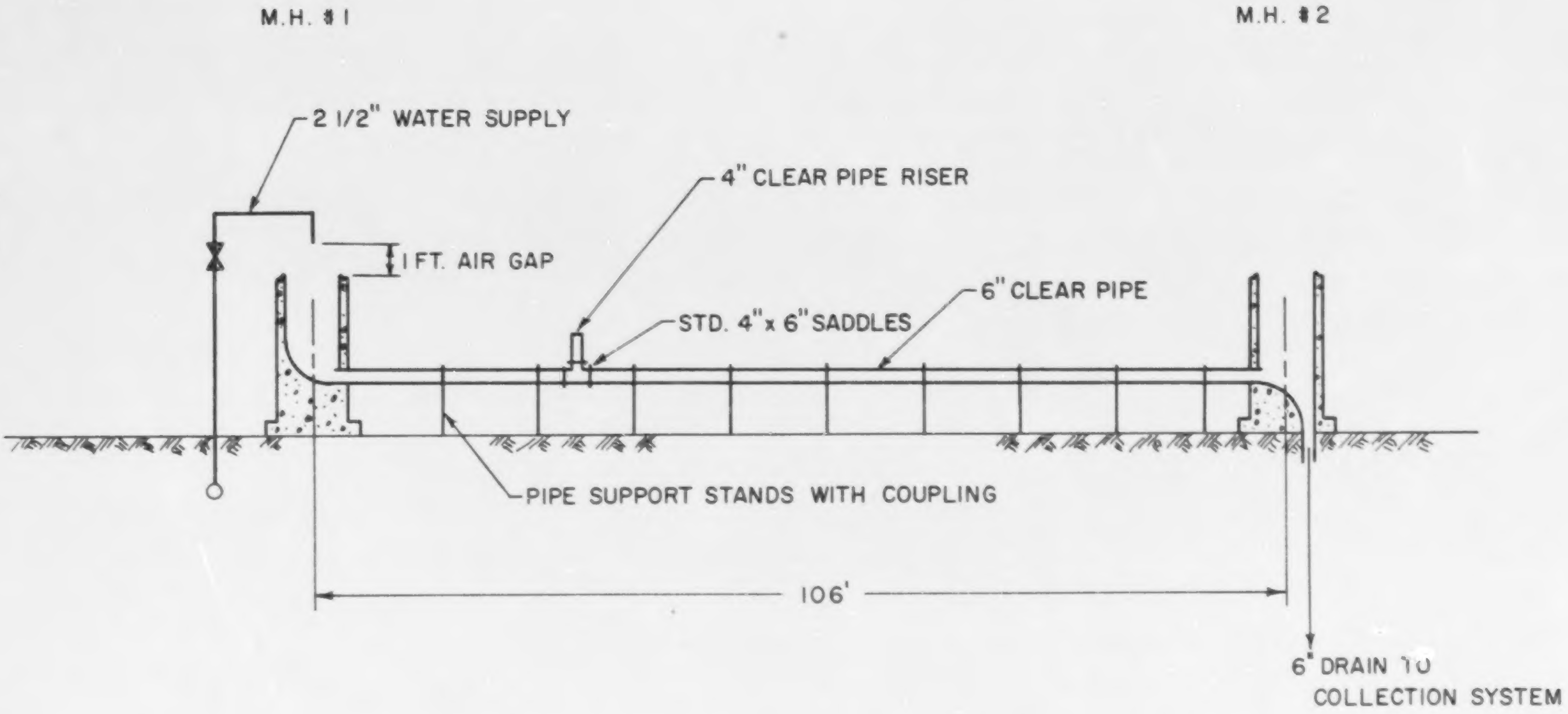
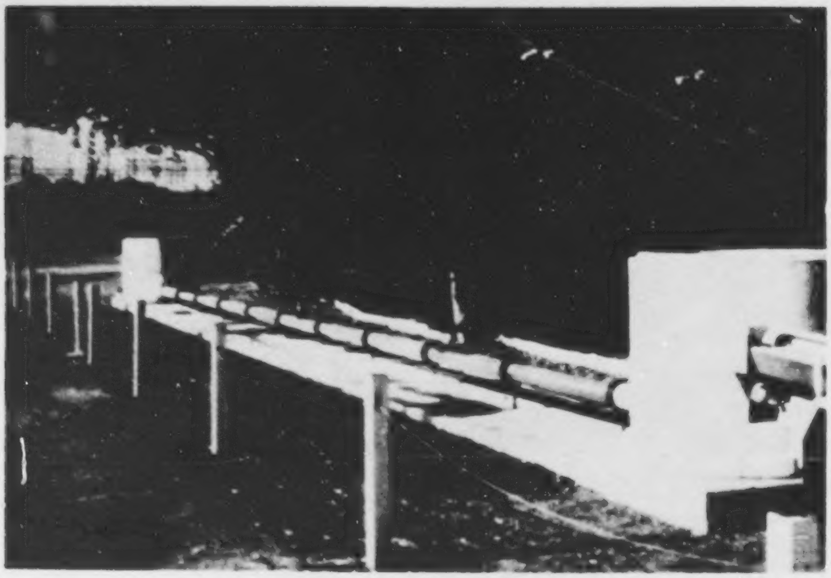
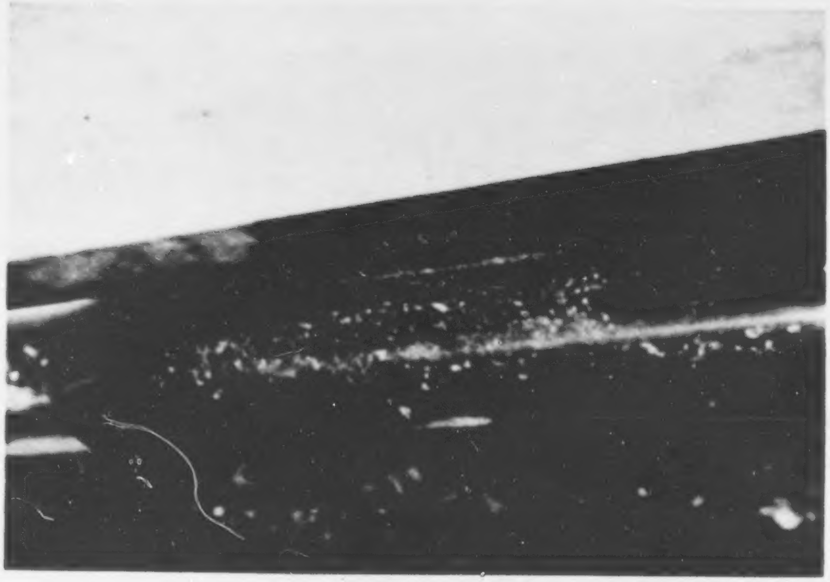

M.H. #1
M.H. #2
2 1/2" WATER SUPPLY
4" CLEAR PIPE RISER
1 FT. AIR GAP
6" CLEAR PIPE
STD. 4" x 6" SADDLES
PIPE SUPPORT STANDS WITH COUPLING
106'
6" DRAIN TO
COLLECTION SYSTEM

Fig. 11.2. Training facility.



Entire facility



Cleaning action of sewer ball

Fig. 11.3. Actual training facility.
(Courtesy Sacramento County)

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Observing the action of a piece of cleaning equipment on some grit or other test material in the clear pipe can be very helpful to a crew. The procedure is very simple. Deposit grit or test material in the upstream manhole (MH #1), turn on the water supply and flush the material into the section of clear pipe. Use the cleaning equipment the crew is working with to remove the grit. The crews can observe the effectiveness of the equipment, its limitations and how to use the equipment as efficiently as possible. Four hours of planned instruction using the training facility can be worth more than several months of on-the-job training in the field.

QUESTIONS

11.4A After a review of Clearwater's preventive maintenance records, what appeared to be the greatest problem and the probable causes?

11.4B How can the condition of a wastewater collection system be determined?

11.4C What are the advantages of video taping what is observed by the TV camera?

11.4D Why is a section of clear pipe a helpful training facility?

11.44 Equipment for Preventive Maintenance Crews

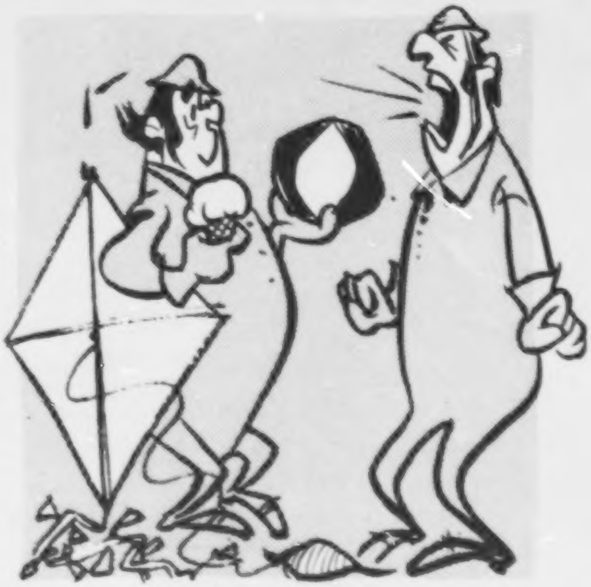
Existing equipment and operation of the preventive maintenance units (crews) is reviewed by the Superintendent of the Senior Collection System Supervisor (maintenance supervisor) in charge of preventive maintenance. They prepared the following list of equipment and procedures used for different cleaning jobs (for details on how to set up and operate the equipment, see Chapter 5, Pipeline Cleaning and Maintenance Methods).

1. Power rodding machine. One is truck mounted and the other is trailer mounted.

   This equipment is quite versatile in some types of cleaning and maintenance. A power rodder is very effective in clearing a stoppage. The large assortment of tools that are available for use with the rodder allows it to be used for clearing various types of stoppages, cutting roots, grease and even clearing sand and grit -- although not too effectively. Effectiveness in larger lines is reduced because of the tendency for the rods to coil and bend. Common procedure is to operate from the downstream manhole, especially when there is a stoppage in the line.

2. Sewer Ball, Cone and Kite. The sewer ball is constructed of high grade rubber and is a ball with spiral ribbing so designed in order to create a spiral action of water in the line. Sewers are cleaned and scoured by the water flowing around the ball at a high velocity.

   The ball comes in assorted sizes and is inflated with air. At each end there is a lug or ear molded into the ball for attachment of a tag line or cable. The ball is inserted at the upper manhole. Air pressure in the ball should be enough to allow heavy flows of water to escape through the ribs on the ball. The tag line, or cable, is threaded through a manhole jack to the surface at a winch where it is controlled by an operator.



Water is introduced into the manhole and allowed to build up until two feet of head has been developed to create cleansing velocities around the ball. The speed of the ball moving down the line is controlled by the operator manning the upstream tag line. Crews must be trained to select the proper speed so the water passing around the ball will "wash" the material in the sewer down the line ahead of the ball. The cone and kite operate in a similar manner.

These pieces of equipment are effective in moving grit, sand and debris down the line to a manhole where it is removed. Slime and grease can be removed from the sides of the pipes by these techniques. One of the undesirable features of using this equipment is the possibility of flooding basements which are located below grade level. If water head behind the cleaning equipment is not properly controlled, flooding may result and could cause considerable damage.

3. Bucket Machines. The bucket machine consists of two power winches with cables running between the winches. When cleaning a section of line, the winches are centered over two manholes. To get the cable from one winch to the other, it is necessary to thread the cable through the sewer line by using a power rodder, parachute, float, or a high velocity cleaner. The cable from the drum of each winch is fastened to the barrel on each end of an expansion bucket so that the bucket can be pulled in either direction by the winch machine on the appropriate end. The bucket is fitted with a closing device and operates somewhat like a clam.

   When a stoppage has been opened and the backed up water has been released, usually the large volume of debris that created the stoppage must be removed. If a bucket machine is used to remove the debris, the cable must be threaded through the stoppage area using a power rodder, high velocity cleaner, or by floating. Once a cable is threaded through the restricted section from an upstream manhole to a downstream manhole, the bucket machine winches may be set up and the line cleaned.

   A bucket machine is pulled into the stoppage in the line until the operator feels that it is loaded with debris.

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The winch motor then is thrown out of gear and the opposite winch is put into action. When the reverse pull is started, the loaded bucket automatically closes and the debris is brought out through the manhole to the surface. The bucket is opened and the debris is deposited in a truck or on the ground or street surface. This operation is repeated until the line is clean. Units with conveyor truck loading mechanisms are available for a much neater operation. Clearwater does not have a conveyor truck loading mechanism.

Various bucket sizes are available for cleaning lines from six inch up to thirty-six inch. Buckets commonly are used for larger diameter lines because of the expense incurred for this type of cleaning. Bucket machine cleaning is effective in removing heavy concentrations of sand and debris from larger diameter lines, but is undesirable from the standpoint of damage that can be done to the lines and because it is a time consuming operation.

4. Sewer Scooter. The sewer scooter creates high velocities of water that clean the walls of sewers. Like the ball, cone and kite, the sewer scooter depends entirely on the head of water behind the scooter to provide the cleaning velocity. The scooter runs on a sled like apparatus that has wheels on the runners and a hinged gate affair to control the upstream water pressure. Drawbacks include being difficult to use in smaller manholes. An effective job is done in removing debris, grease and slime from the line.

5. High Velocity Cleaning Machines. High velocity cleaning machines are truck mounted and usually carry 500 to 700 feet of hose capable of withstanding high pressures. Special nozzles can be attached to the hose for routine

cleaning and for breaking stoppages in a sewer. These nozzles have jets at various angles in the rear and they serve a dual purpose. They propel the hose up the sewer and cut or move material in the sewer at the same time. High velocity cleaning machines are probably the most effective of the cleaning tools for removing grease, grit, sand, gravel, and debris. Traps always should be used with this operation to trap all debris and keep it from traveling farther downstream.

A limitation of high velocity cleaners is their ineffectiveness in areas that have steep grades. Sometimes they do not have sufficient water pressure to propel the nozzle up a line in areas of steep grades. Another problem is the danger of flooding a residence if it is not properly used. In any case, the operator should be an experienced worker well versed in what could take place if the high velocity cleaning machine is not properly used.

6. Flushing. Flushing plays an important part in cleaning small sewers for short distances. Although flushing does not scour or clean the sewers of grease or grit, it does give the opportunity to inspect each manhole and flushing inlets. The main purpose of this operation is to thoroughly clean the manhole in the system and move any floatable debris downstream to a larger trunk line. Occasionally, flushing helps locate a potential stoppage in the collection system.

7. TV Unit Not Available to Clearwater Yet. The TV unit is contained in a van or specially designed trailer and is available in many models, some being very sophisticated pieces of equipment. Basically, the TV unit serves one very important purpose -- to inspect the collection system. Closed circuit television may be used to locate infiltration, root instrusion, cracks and breaks in the line, offset joints, building sewers, lost manholes, and almost anything that one would want to see in the system. TV units are extremely helpful in allowing evaluation of the effectiveness of cleaning techniques.

8. Records. A simple and useful type of record keeping system must be implemented and maintained when setting up a preventive maintenance program. Accurate records are one of the most valuable tools available for a maintenance department. The record cards aid the department in a number of ways. Information that collection system records should provide are as follows:

   1. Details of all work done on the system, including dates
   2. Assistance in scheduling future work
   3. Justification for annual budget
   4. Documentation for annual budgets
   5. Protection of liability of the agency.

   A record card file system should be kept giving all pertinent data of the collection system and maintenance performed on it. Records should be kept up to date, thus providing an accurate record of all work performed and all recurring sources of trouble in a collection system (see Chapter 10, Section 10.2, Records, for details).

9. Summary. All of the items and equipment that have been mentioned were designed for a specific task and cannot be used to remedy all of the situations that may occur in a collection system.

QUESTIONS

11.4E Why did the Superintendent list the equipment used for cleaning wastewater collection lines?

11.4F Could one piece of equipment be used to solve all collection line problems?

11.45 Preventive Maintenance Section Functions and Guidelines

11.451 Work Schedule

A wastewater collection system cleaning schedule is developed by the Senior Collection System Supervisor and the Superintendent. The schedule should be reviewed by the engineering staff.

11.452 Priority List

A priority list helps to provide an organized approach to solving problems when they develop and insuring the completion of necessary work. Clearwater developed the following priority list:

1. Assist emergency service crew to clear difficult stoppages on request.
2. After emergency service crew reports the clearing of a main line stoppage, clean segment of line where stoppage occurred within three days.
3. In lines with known root problems, schedule power rodder to clear problem areas. If emergency service crews receive requests for same location more than once in a six-month period, schedule power rodder in problem area more frequently and try to control roots using chemicals (Chapter 5, Section 5.5, Chemicals).
4. Where lines have grease problems, schedule high velocity cleaner to clean lines more often where service requests indicate a more frequent schedule is necessary.
5. Assign cleaning units to areas of collection system to be cleaned this year.

11.453 Special Projects

1. Construct training facility (Figs. 11.2 and 11.3) and provide training sessions for all preventive maintenance cleaning crews.

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2. Develop priority list of portions of collection system to be inspected by rented closed circuit television inspection unit.

3. Prepare and schedule program to chemically treat fifteen miles of sewers with serious root problems (see Chapter 5, Section 5.53, Roots). Program should include the following items:

   a. Research literature for available chemicals, methods and success of attempts by others to chemically treat lines to control roots.

   b. Visit communities with similar problems using chemicals to control roots and evaluate effectiveness of their efforts and discuss with them their ideas for better results.

   c. Select at least two methods of chemical treatment and test each on a section in selected area to evaluate effectiveness of methods.

   d. Keep records of all aspects of chemical treatment program including labor, equipment and chemicals to evaluate cost effectiveness of program.

11.46 Organization of Preventive Maintenance Section

Based on the needs and priorities previously discussed, the preventive maintenance section is organized as follows:

11.461 Manpower

1. Two power rodder crews.

   One crew is assigned to collection system line preventive maintenance. The other crew assigned to work with the rented TV unit to operate the TV unit and to power rod known difficult or problem sections in the lines before TV inspections.

2. One high velocity cleaner crew.

   This crew will be assigned to clean lines with known grease problems on a regular frequency based on service requests and a schedule developed by the Senior Collection System Supervisor (Maintenance Supervisor). Also, this crew will assist the emergency service request crews with the clearing of stoppages when help is needed and hose down and clean up lift station wet wells every three months.

3. Three balling crews.

   Balling crews are placed on a two-year cleaning program to clean every segment of the collection system at least once every two years.

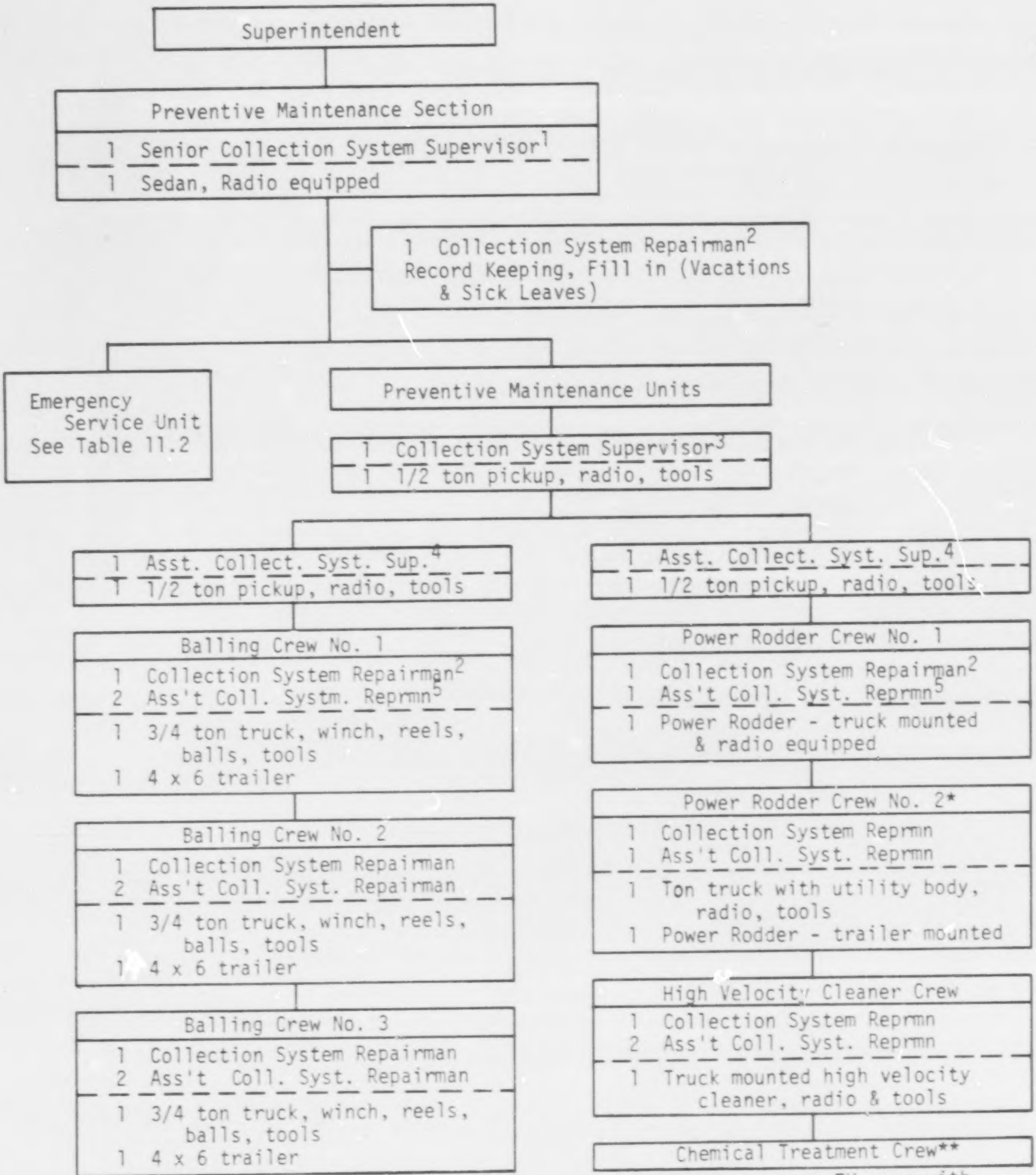
11.462 Equipment

For details regarding the equipment requirements for the crews, see Chapter 5, Pipeline Cleaning and Maintenance Methods.

11.463 Organization Chart

The organization chart for the preventive maintenance section, Table 11.3, shows the emergency service request crews and the preventive maintenance crews both under the direct supervision of a Senior Collection System Supervisor (Maintenance Supervisor). This arrangement recognizes the interrelationships between the units and the need for coordination and cooperation.

TABLE 11.3. PREVENTIVE MAINTENANCE SECTION ORGANIZATION, STAFFING AND EQUIPMENT


Superintendent
Preventive Maintenance Section
1 Senior Collection System Supervisor[1]
1 Sedan, Radio equipped
1 Collection System Repairman[2]
Record Keeping, Fill in (Vacations & Sick Leaves)
Emergency Service Unit
See Table 11.2
Preventive Maintenance Units
1 Collection System Supervisor[3]
1 1/2 ton pickup, radio, tools
1 Asst. Collect. Syst. Sup.[4]
1 1/2 ton pickup, radio, tools
Balling Crew No. 1
1 Collection System Repairman[2]
2 Ass't Coll. Systm. Reprmn[5]
1 3/4 ton truck, winch, reels, balls, tools
1 4 x 6 trailer
Balling Crew No. 2
1 Collection System Repairman
2 Ass't Coll. Syst. Repairman
1 3/4 ton truck, winch, reels, balls, tools
1 4 x 6 trailer
Balling Crew No. 3
1 Collection System Repairman
2 Ass't Coll. Syst. Repairman
1 3/4 ton truck, winch, reels, balls, tools
1 4 x 6 trailer
1 Asst. Collect. Syst. Sup.[4]
1 1/2 ton pickup, radio, tools
Power Rodder Crew No. 1
1 Collection System Repairman[2]
1 Ass't Coll. Syst. Reprmn[5]
1 Power Rodder - truck mounted & radio equipped
Power Rodder Crew No. 2*
1 Collection System Reprmn
1 Ass't Coll. Syst. Reprmn
1 Ton truck with utility body, radio, tools
1 Power Rodder - trailer mounted
High Velocity Cleaner Crew
1 Collection System Reprmn
2 Ass't Coll. Syst. Reprmn
1 Truck mounted high velocity cleaner, radio & tools
Chemical Treatment Crew**

1. Maintenance Supervisor
2. Maintenance Man II or Maintenance Equipment Operator
3. Foreman
4. Foreman
5. Maintenance Man I

* This crew becomes TV crew with addition of 1 TV system operator

** Balling Crew will be used for this operation during interim testing and evaluation period.

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QUESTIONS

11.4G Why should a priority list be developed for scheduling work by preventive maintenance crews?

11.4H What is the priority list developed by Clearwater for the preventive maintenance crews?

11.4I What items should be considered during the preparation and scheduling of a chemical treatment program for root control?

11.4J How many crews will be in Clearwater's Preventive Maintenance Units?

11.4K How many collection system workers will be under the supervision of the Preventive Maintenance Unit's Collection System Supervisor?

11.5 COLLECTION SYSTEM REPAIR AND NEW CONSTRUCTION

11.51 Scope of Work

All repairs to sewer and manholes and installation of new sewers and manholes (within the limitations of equipment, manpower and time) are done by this section. To determine whether or not a project should be undertaken by this section or by a private contractor, a set of guidelines were developed. A private contractor should be considered if the following conditions exist:

1. Material for a single job is over $8,000. This value is a flexible guideline and depends on how busy repair crews are when job needs to be done and the desires and ability of local contractors to do the job.

2. Time to complete the job is more than ten days. Again this time period is a flexible guideline and depends on how busy repair crews are when needed and the desire and ability of local contractors. Repair crews should not become involved in large jobs requiring over ten days because they have other work that should be done. Also competitive bidding among contractors may get the job done at a reasonable price. Repair crews should do emergency work if necessary and obtain assistance from contractors without bids for critical emergency jobs.

3. Special construction or safety equipment will be required. Examples of special equipment include deep shields for shoring or considerable pumping capacity to dewater excavations in areas with a high water table.

The repair and construction section consists basically of two units. One unit will specialize in doing repairs in easements and service lines where most of the work will require hand digging because of limited access for equipment. The other unit will install new services and manholes and repair main lines in the streets or other open areas where mechanical equipment such as backhoes may be used.

Activities of the collection system repair and new construction section are developed by the Superintendent and the section's Senior Collection System Supervisor. They outlined the following tasks for Clearwater's program;

11.511 Repair Crews

1. System repair on basis of work order requests from emergency service and preventive maintenance crews.

2. Senior Supervisor to review each work order card and to assign priority to jobs. Priority assignment will be either immediate repair or repair when time available. Jobs will be assigned to the appropriate unit.

3. Safety orders to be followed by all workers.

4. All field workers must attend shoring school once a year.

SHORING
SCHOOL

5. Field crews working in easements and back yards must show proper respect for private property. Every effort must be made to restore area to original conditions, including replanting lawns and replacing shrubbery.

   Trees interferring with collection system or repair of system are to be removed and should not be replaced in easement.

6. Whenever possible all excavations should be filled at the end of each day. Work overtime if necessary. Any open excavations must be covered with adequate strength materials and properly marked with signs, barriers and flasher signals.

7. All tap repairs and new taps will be made by repair section. Plumbers will not be allowed to make any taps into Clearwater's collection system.

8. All main line stoppages that require digging will have wastewater pumped from upper manhole to lower manhole, thus isolating the portion of line under repair. Under no circumstances will raw wastewater be by-passed into a storm drain or open water course.

11.512 New Construction Crews

1. New system work will be completed on the basis of work order requests from emergency service and preventive maintenance crews. New service connections will require building permits and other necessary permits.

2. A flat fee will be charged for single family residence service connections. Commercial and industrial connections will be charged on basis of a field cost estimate by the New Construction Unit Supervisor. Supervisor to contact Industrial Waste Supervisor on all commercial and industrial connections for special equipment. This equipment will meter and sample effluent to meet sewer-use ordinance requirements for billing and compliance with waste discharge requirements.

3. Senior collection system repair supervisor should periodically review the section's organization. Consideration should be given to expanding crews during the dry summer months for repairs. Permanent crew size should be small because repair digging should be minimized during wet weather, except for emergencies.

4. Collect cost data and compare economics of purchasing heavy equipment (5-yard dump trucks and backhoes) with renting necessary equipment. Clearwater needs one backhoe for use throughout the entire year and three backhoes for repair work during the eight-month dry season.

5. Rental of a closed circuit television inspection unit for one month is expected to reveal considerable work for the repair unit. Experience by other agencies indicates that for every eight hours of collection system TV inspection, 24 hours of repair work will be discovered consisting of the following:

   a. Bad taps (including protruding taps)

   b. Bad joints

   c. Offset joints

   d. Broken pipes

   e. Deteriorated pipe.

11.52 Equipment

Equipment needs for this section are discussed in the following paragraphs and also in Chapter 6, Underground Repairs.

11.521 Repair Unit

Equipment to install cleanouts, backwater valves, overflow valves, and to make repairs in rear easements will require a one-ton flatbed truck and hand tools. The truck should have tool compartments for small expensive tools that can be easily damaged, lost or stolen. Keep these tool compartments locked.

A partial fixed or sliding-top canopy which provides protection from the weather and working space on the job is very helpful. This type of truck should fit the particular needs of the agency to increase efficiency and at the same time to present a pleasing appearance.

11.522 New Construction Unit

Well-planned and well-equipped construction trucks are necessary for an agency responsible for the maintenance and repair of a small or large collection system. These trucks must be rugged and compact if they are to carry the number and variety of tools and materials required in emergency repairs or new construction work. An air compressor of sufficient capacity is the heart of all operations and is often carried at the rear of the cab. Outlets and piping for air can be placed around the truck body. Such a truck will be larger than a truck used to tow a trailer-mounted compressor. Locked compartments for small tools are highly desirable, as is a central space of sufficient size to permit transportation of lumber, pipe, cement, shoring or other materials. Water tanks hung under the truck sides are desirable for use in mixing small quantities of concrete on the job. An electrical generator power take-off of sufficient voltage to permit operation of small electric tools or lights is very valuable.

Size and design of trucks are regulated by the requirements and by the money available to your agency. Trucks used by brick masons may be similar except that the bed should be divided by foot-high compartments in which sand, rock, bricks, and cement may be placed, and a space provided for the debris which must be hauled away after the job is completed.

Trucks used in the regular program of cleaning sewers can be similar to the trucks used for inspection except that the bodies should be longer to take care of larger tools and equipment needed for sewer scooters or large sewer balls and cones. Trailer hitches for towing cleaning trailers or dump trailers are essential. The sizes and arrangement of compartments will differ from the inspection truck, but the sliding canopy need not change.

As all of the trucks mentioned so far are required to stand or operate in fast-moving traffic or heavily traveled highways, they should be painted a bright color, with reflective striping across the rear portions. Amber blinking lights for night protection, roadway flares, and barricade light blinkers are a necessity. An electrical generator or power converter also is desirable when inspection lights and flood lights are needed, and outlets should be provided at a convenient location on the truck.

Whenever possible, all critical operating units should be equipped with two-way radio telephones or portable radio receivers and transmitter units. This will permit an emergency call to be dispatched and answered in a matter of minutes or within the hour of being received.

11.53 Organization of Repair and New Construction Section

This section's organization chart is contained in Table 11.4.

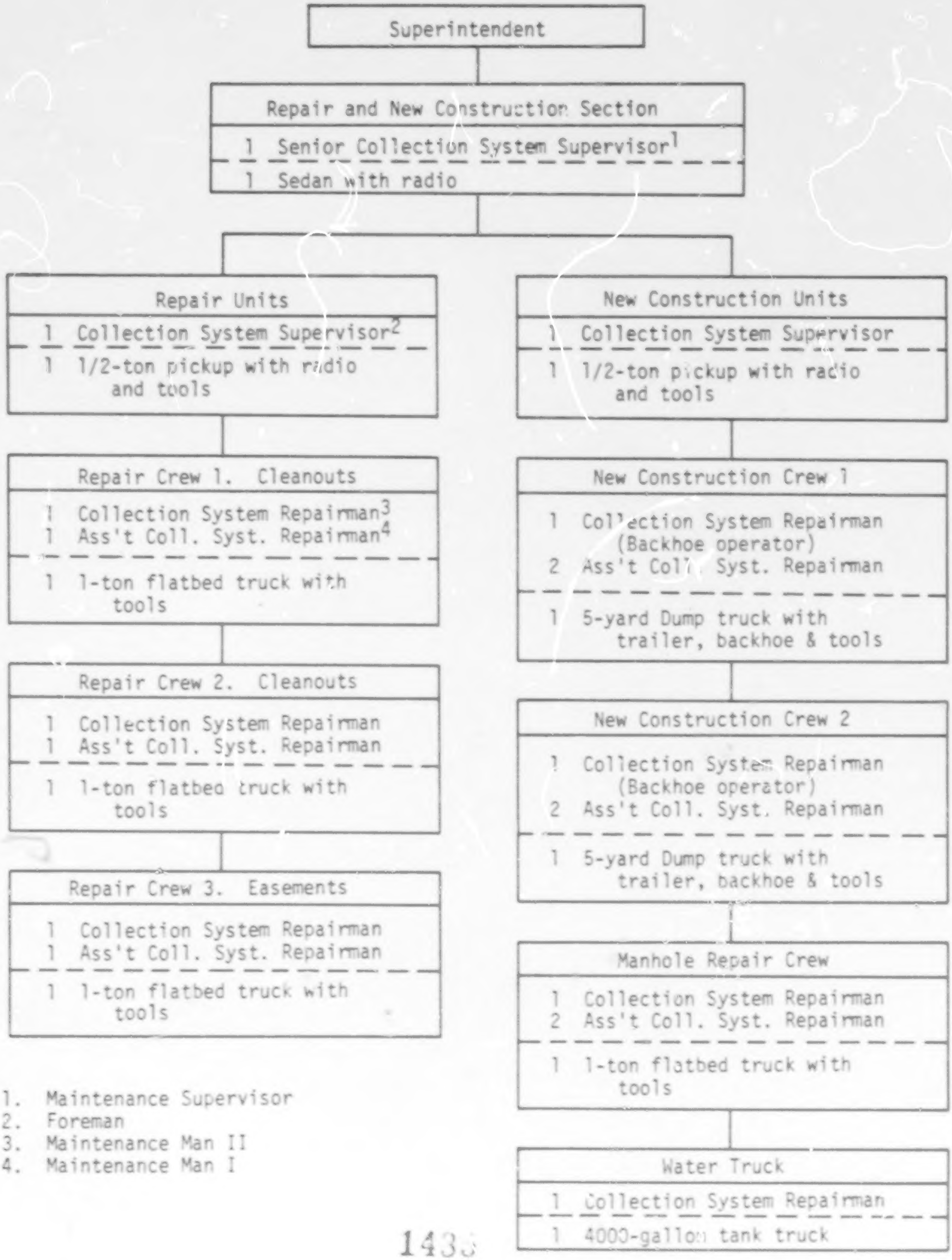
QUESTIONS

11.5A What factors should be considered by Clearwater when trying to decide whether repair or construction should be done by the agency or by a private contractor?

11.5B What is the difference between Clearwater's two units in the Repair and New Construction section?

11.5C What are the priority designations given repair work?

TABLE 11.4. REPAIR AND NEW CONSTRUCTION ORGANIZATION STAFFING AND EQUIPMENT

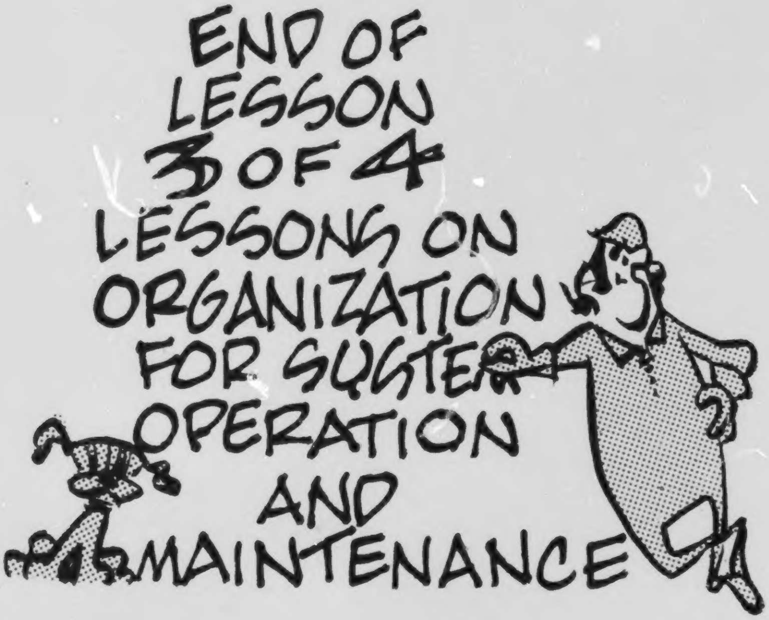

Superintendent
Repair and New Construction Section
1 Senior Collection System Supervisor[1]
1 Sedan with radio
Repair Units
1 Collection System Supervisor[2]
1 1/2-ton pickup with radio and tools
Repair Crew 1. Cleanouts
1 Collection System Repairman[3]
1 Ass't Coll. Syst. Repairman[4]
1 1-ton flatbed truck with tools
Repair Crew 2. Cleanouts
1 Collection System Repairman
1 Ass't Coll. Syst. Repairman
1 1-ton flatbed truck with tools
Repair Crew 3. Easements
1 Collection System Repairman
1 Ass't Coll. Syst. Repairman
1 1-ton flatbed truck with tools
New Construction Units
1 Collection System Supervisor
1 1/2-ton pickup with radio and tools
New Construction Crew 1
1 Collection System Repairman (Backhoe operator)
2 Ass't Coll. Syst. Repairman
1 5-yard Dump truck with trailer, backhoe & tools
New Construction Crew 2
1 Collection System Repairman (Backhoe operator)
2 Ass't Coll. Syst. Repairman
1 5-yard Dump truck with trailer, backhoe & tools
Manhole Repair Crew
1 Collection System Repairman
2 Ass't Coll. Syst. Repairman
1 1-ton flatbed truck with tools
Water Truck
1 Collection System Repairman
1 4000-gallon tank truck

1. Maintenance Supervisor
2. Foreman
3. Maintenance Man II
4. Maintenance Man I

11.5D Work orders for new construction crews originate from what sources?

11.5E Closed circuit television inspection will reveal what types of repair work?

11.5F Where should small, expensive hand tools be kept in trucks?


END OF
LESSON
3 OF 4
LESSONS ON
ORGANIZATION
FOR SYSTEM
OPERATION
AND
MAINTENANCE

DISCUSSION AND REVIEW QUESTIONS

Chapter 11. Organization for System Operation and Maintenance
(Lesson 3 of 4 Lessons)

Write the answers to these questions in your notebook before continuing. The problem numbering continues from Lesson 2.

12. How would you attempt to evaluate the condition of a wastewater collection system?
13. What are the advantages of a training facility built with clear plastic pipe above ground?
14. What kind of work is done by a preventive maintenance crew?
15. How would you develop a priority list for scheduling preventive maintenance crews?
16. How would you determine whether or not to consider a private contractor for a sewer repair job?
17. What equipment is needed by repair crews and new construction crews?

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11.6 LIFT STATION OPERATION AND MECHANICAL MAINTENANCE

11.61 Scope of Work

A review of the operation and maintenance of wastewater and storm water lift stations by the Superintendent indicated existing procedures were fairly effective. Work priorities for this section are as follows:

1. Respond to all lift station failures when notified by dispatcher or by Police Department during off-duty hours.
2. Assist other sections in setting up emergency pumps to prevent flooding of homes or businesses or by-passing of raw wastewater to drainage ditches.
3. Respond to alarms from telemetered system.
4. Perform all lift station maintenance except machine shop work which will be done immediately upon notice by local machine shops under contract with City of Clearwater.
5. Perform work on preventive maintenance schedule and work requests from other sections.
6. Senior Mechanical Supervisor (Maintenance Supervisor) to evaluate and establish a program that will change daily lift station inspections to a monthly inspection. Change will be accomplished by establishing a preventive maintenance program, a telemetering system, and increasing capacity of lift station auxiliary units such as oilers and reservoirs to operate for one month without service.

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11.62 Lift Station Failures (Also see Chapter 7, Lift Stations)

A properly designed pump used in a wastewater lift station, although properly maintained, can fail to operate when least expected and usually when needed most. There are at least three reasons why a pump will fail to function. The pump may fail due to either a malfunction in the electrical system, in the mechanical system or by debris plugging an impeller or jamming a check valve.

Electrical failure may be the result of a power failure or an outside power source being switched off due to a circuit overload on the main power source. A circuit breaker kick out due to a circuit overload in the station itself could cause an electrical failure. A quick check of the reset button or breaker switch could identify the electrical failure caused by an in-station overload kick out. When manual reset solves the problem temporarily but kicks out the reset or breaker switches (thermal overloads) again after a few moments of lift station operation, do not attempt to restart the pumps until a thorough inspection has been made of the pumping equipment in the lift station to find the problem. Correct situation before attempting to restart.

DO NOT ATTEMPT RRECT THE ELECTRICAL
PROBLEM UNLE YOU ARE QUALIFIED AND
AUTHORIZED BY YOUR AGENCY.

If the problem has been located and corrected, reset electrical breaker and put lift station back on line. If the reset breakers kick out again, shut down associated equipment. Do not attempt to correct the electrical problem unless you are qualified and authorized by your agency.

An overload may be caused by an electrical short in the motor or wiring control system, a mechanical part failure putting a load on the motor, or a plug in the impeller causing a load on the motor.

A mechanical failure could result from the breakdown of a bearing, poor shaft alignment, vibrations, mechanical seal failure, or malfunction of a mechanical float switch unit. Bearing breakdown can be noticed by a noise, vibration or heat at the breakdown location. Other mechanical breakdown could be a malfunction in the check valves, air bubbler compressor, and switching units associated with the centrifugal pump.

In the pneumatic ejector type of lift station, mechanical problems are generally caused by a check valve malfunction on the intake or discharge pipe valves. Air compressor and control for air by-pass valves are other items which may fail.

The shorting of the control electrode by grease or corrosion is one electrical problem found at times in pneumatic ejector type stations. Cycle timing device unit also can cause problems.

In the centrifugal type pump, most common pump failures are caused by debris piled up in the impeller area. Common material found in stopped impellers include lodged sticks, wooden blocks, bricks, rocks, rags, mops, plastic bags, sacks, stringy material, and roots.

If a lift station cannot be put back on line before flooding, emergency pumps should be set up and piping arranged to pump the station's influent from the wet well into the force main until the problem can be corrected.

11.63 Preventive Maintenance Schedule

A preventive maintenance schedule should be established to take care of every item in the lift station including lubricating the front door locks, replacing light bulbs and sweeping the floor. A very thorough and well thought out schedule that includes minor items will usually have provisions for maintenance of all the major pieces of equipment.

11.64 Organization of Mechanical Maintenance Section

Lift station operation and mechanical maintenance are the responsibility of the Mechanical Maintenance Section whose organization is shown in Table 11.5.

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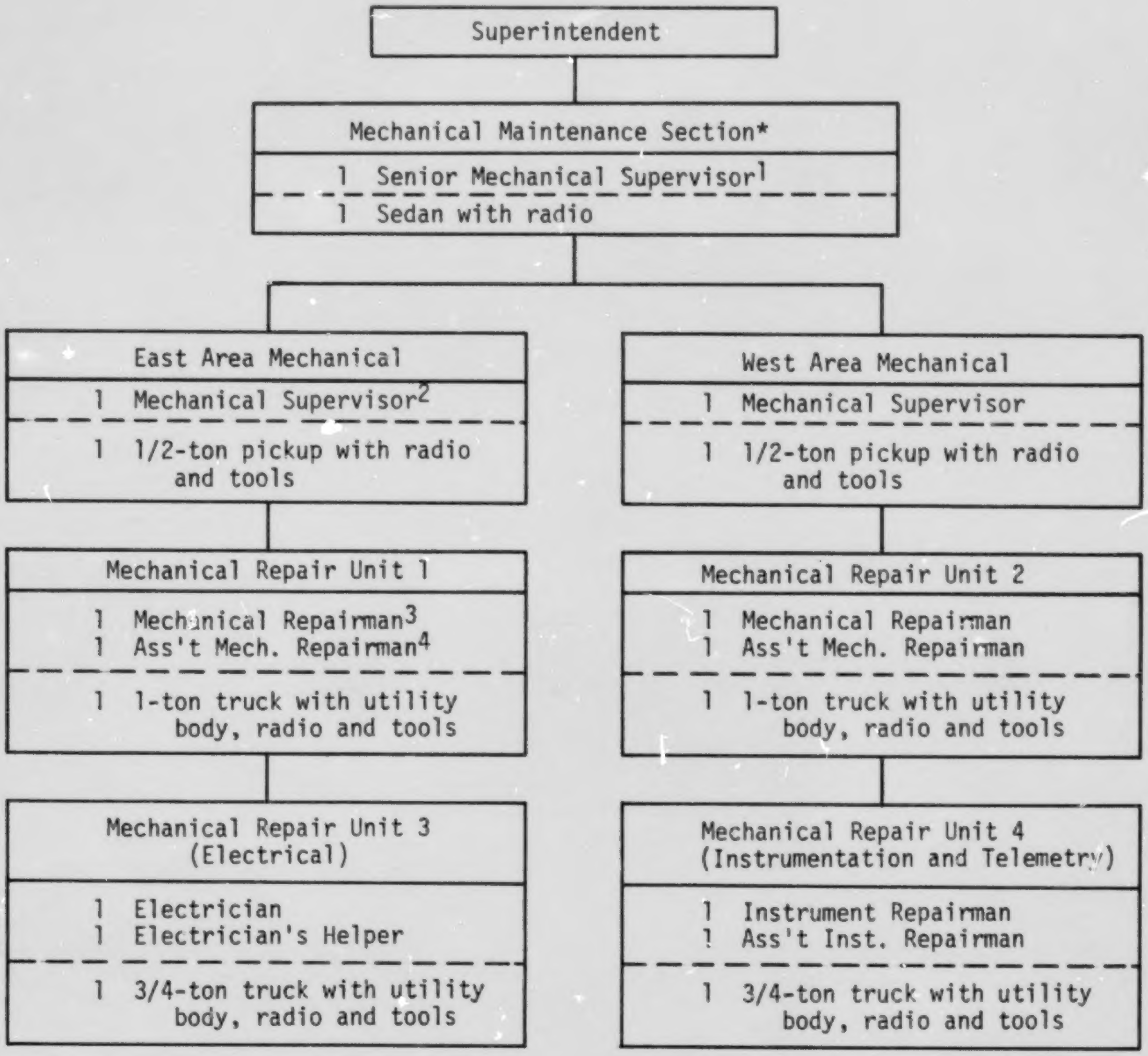
TABLE 11.5. MECHANICAL MAINTENANCE SECTION ORGANIZATION, STAFFING AND EQUIPMENT


Superintendent
Mechanical Maintenance Section*
1 Senior Mechanical Supervisor1
1 Sedan with radio
East Area Mechanical
1 Mechanical Supervisor2
1 1/2-ton pickup with radio and tools
West Area Mechanical
1 Mechanical Supervisor
1 1/2-ton pickup with radio and tools
Mechanical Repair Unit 1
1 Mechanical Repairman3
1 Ass't Mech. Repairman4
1 1-ton truck with utility body, radio and tools
Mechanical Repair Unit 2
1 Mechanical Repairman
1 Ass't Mech. Repairman
1 1-ton truck with utility body, radio and tools
Mechanical Repair Unit 3 (Electrical)
1 Electrician
1 Electrician's Helper
1 3/4-ton truck with utility body, radio and tools
Mechanical Repair Unit 4 (Instrumentation and Telemetry)
1 Instrument Repairman
1 Ass't Inst. Repairman
1 3/4-ton truck with utility body, radio and tools

* Provides mechanical, electrical and instrumentation support to wastewater treatment plant.

1. Maintenance Supervisor
2. Foreman
3. Maintenance Man II
4. Maintenance Man I

QUESTIONS

11.6A What are the work priorities for Clearwater's lift station operation and mechanical maintenance section?

11.6B How can Clearwater change the program of daily visits to lift stations to monthly visits without encountering problems?

11.6C What are the major causes of lift station pump failures?

11.6D What could cause an electrical failure?

11.6E Under what circumstances may repair work on an electrical system be attempted?

11.7 INDUSTRIAL WASTE SECTION

11.71 Scope of Work

Clearwater has formed a new Industrial Waste Section to enforce the Sewer-use Ordinance. Information also is needed to establish monthly charges to commercial and industrial wastewater discharges. The priority work list for the Industrial Waste Section is as follows:

1. Inspect and monitor discharges for violation of Sewer-use Ordinance. Look for activities and discharges that could damage the wastewater collection system or the processes and facilities at the wastewater treatment plant.
2. Monitor industrial and commercial users' flows and organic (BOD and suspended solids) discharges to determine monthly sewer-use charges.

3. Locate sources of reported dumpings or bypasses that upset wastewater treatment processes or are detected by collection system preventive maintenance crews. Make recommendations and provide evidence to person or agency responsible for issuing cease and desist orders to violators of Sewer-use Ordinance.

4. Collect samples and deliver to laboratory at wastewater treatment plant.

CEASE
AND
DESIST

5. Provide assistance for metering and collecting data for special studies, such as inflow-infiltration, conducted by preventive maintenance and mechanical maintenance crews. Crew assignments include metering flows, taking grab and composite samples, running dye tests, smoke testing lines, inspecting waste dischargers for type of equipment processes, and chemicals used that may accidentally be discharged to the wastewater collection systems by spills or dumps.

11.72 Equipment for Industrial Waste Section

With increasing size and age of wastewater colleciton systems, maintenance equipment needs become more specialized. This equipment usually is costly, but occasionally modified versions of standard pieces of equipment can be used.

For example, in every system there is the possibility that explosive gases will enter confined spaces from leaks and breaks in adjacent utility lines, from the flushing of spilled petroleum products, or from the direct discharge of these products through house, commercial or industrial lateral connections. Some of the destructive and fatal explosions which have occurred in collection lines and appurtenant structures could have been prevented if proper programs of explosive-gas testing had been in force. Testing equipment installed in a delivery van type truck or in a pickup permits the inspection of from 300 to 500 manholes per day for explosive gases. When a dangerous manhole is found, immediate contact should be made with the gas utility company or emergency unit prepared to deal with the problem.

A one-ton truck with cab and chassis on which is mounted a special enclosed body with a sliding canopy and open center is inexpensive, flexible and neat. Other essential equipment includes a small refrigerator for sample preservation, blowers, lights, meters for flow measurements, gas testing equipment, manhole lifters, small tools, safety harness, ladders, and portable field laboratory equipment. Field laboratory equipment includes pH meters, hydrogen sulfide test kits, various sample containers, composite samplers, and a portable electric generator. Field inspectors should be equipped with a radio-paging device that notifies them to phone the office.

11.73 Organization of Industrial Waste Section

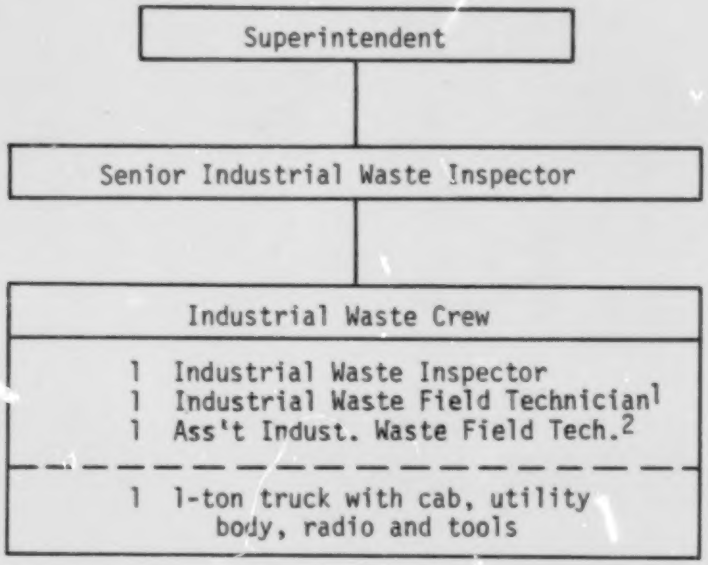
Table 11.6 shows the organization of Industrial Waste Section.

QUESTIONS

11.7A Why did Clearwater form an Industrial Waste Section?

11.7B What is the priority work list for Clearwater's Industrial Waste Section?

TABLE 11.6. INDUSTRIAL WASTE SECTION ORGANIZATION, STAFFING AND EQUIPMENT


Superintendent
Senior Industrial Waste Inspector
Industrial Waste Crew
1 Industrial Waste Inspector
1 Industrial Waste Field Technician[1]
1 Ass't Indust. Waste Field Tech.[2]
1 1-ton truck with cab, utility body, radio and tools

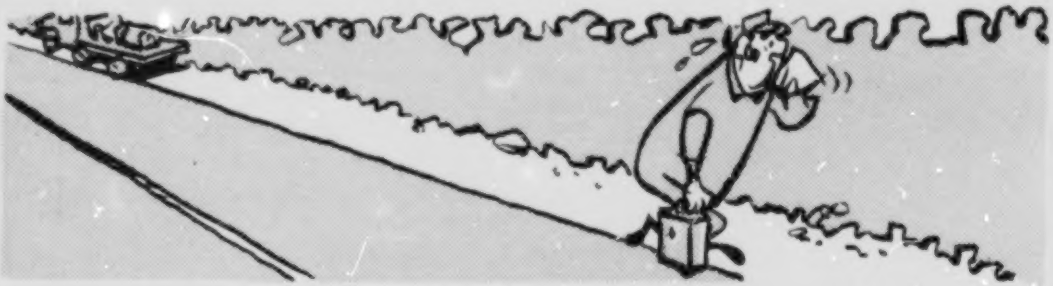
1. Maintenance Man II
2. Maintenance Man I

11.8 ADDITIONAL ESSENTIAL EQUIPMENT

This section describes important pieces of equipment that should be readily available to all crews whenever the need arises.

Collection system operation and maintenance equipment must be geared to 24-hour operation. Consequently, portable equipment must be ready to move at all times.

An air compressor is probably the most useful unit available to a crew because of the many pneumatic tools which it can power. The compressor should have a capacity of at least 150 CFM if two pavement breakers or clay spades are to be operated simultaneously.



Whether the unit should be truck - or trailer-mounted depends on the size requirement.

Gasoline powered wastewater pumps may vary in discharge size from 2 to 8 inches, depending on the size of the sewer to be serviced. Such pumps should be of the non-clogging type, trailer mounted, preferably on four-wheel trailers for the larger sizes, and should be provided with a self-priming unit to save time and effort. Quick-coupling pipe or hose of sufficient length to pump wastewater between manholes or around a break is desirable. A small pneumatic pump makes a good unit to pump out flooded basements and to dewater trench excavations where high lifts are required and the volume is not large. Such a pump may be of either the ejector or centrifugal type. Plungers or low-speed suction pumps also are ideal to dewater trench excavations because their action is positive and constant.

Large portable generators are helpful for providing electricity to lift stations without standby generators during power outages or other electrical interruptions. Trailer or skid-mounted generators can be transported easily by trucks or hydro-lift trucks. Special interlocking outlets must be provided at lift stations so the leads from the generator can be plugged into the proper socket to operate equipment during a power failure.

Good lighting must be available for work at night and also for warning purposes, including warning traffic and pedestrians. Lighting is essential because once repair of a broken line is started, work must continue without stopping until the line is repaired. Occasionally traffic conditions require certain work to be done at night.

Small portable generators are ideally suited to fill this need and, at the same time, they can be used to drive a variety of electrical tools. Where job requirements demand larger flood lights and more power, a trailer-mounted generator with a battery of flood lamps can be used. When inspecting the interior of large sewers, storm drains, or appurtenant structures, a sufficient number of safe lighting units are needed. These units must be explosion proof, double insulated, and properly guarded or protected.

Blowers, either trailer mounted or portable, eliminate any potential or real hazard which may exist in the form of toxic or explosive gases or oxygen deficiency. No inspection of sewers, storm drains or any confined spaces should be made unless proper ventilation is an accomplished fact and tests indicate the atmosphere in which you must work is SAFE.

Trailer-mounted blowers with a capacity up to 7,500 CFM can ventilate easily many feet of medium size sewers. Small portable units that can be carried on a truck and powered by an electric generator or powered through a converter on the truck can provide sufficient air to ventilate any manhole, small pump pit or sump.

Two-way, portable telephone or radio units are most helpful when performing cleaning operations where sighting between manholes may be impossible. On heavily traveled streets it often is impossible for workers to hear each other or to see signals made by crew members. Flooding of basements can be prevented by stationing a worker and radio unit at a suitable location to advise the cleaning crew if a backup occurs. Night work often is required because of daytime traffic and quick, positive intercommunication is always available with radio units. Radio units used for communication by crews working in the field may be on a different radio frequency than the central dispatching system to avoid interference and confusion, provided the additional frequency is available. There are many other possibilities for radio use that can help you do your job quicker and safer.

A chemical spray unit may be very useful for mosquito and odor control.

A concrete mixer of 1/2-sack capacity will provide sufficient concrete for many jobs and can be stored and towed easily. For larger quantities of concrete, ready-mix concrete is probably less expensive. Many other items of equipment can add to the overall efficiency of your agency.

QUESTIONS

11.8A Why is portable equipment necessary?

11.8B List some useful pieces of portable equipment.

11.9 ORGANIZATION OF CLEARWATER'S DIVISION OF WATER RECLAMATION

11.91 Organization Chart

Clearwater's Superintendent has reviewed the program for the next fiscal year, and developed Table 11.7 to show the organization he believes will be able to meet the Division's responsibilities.

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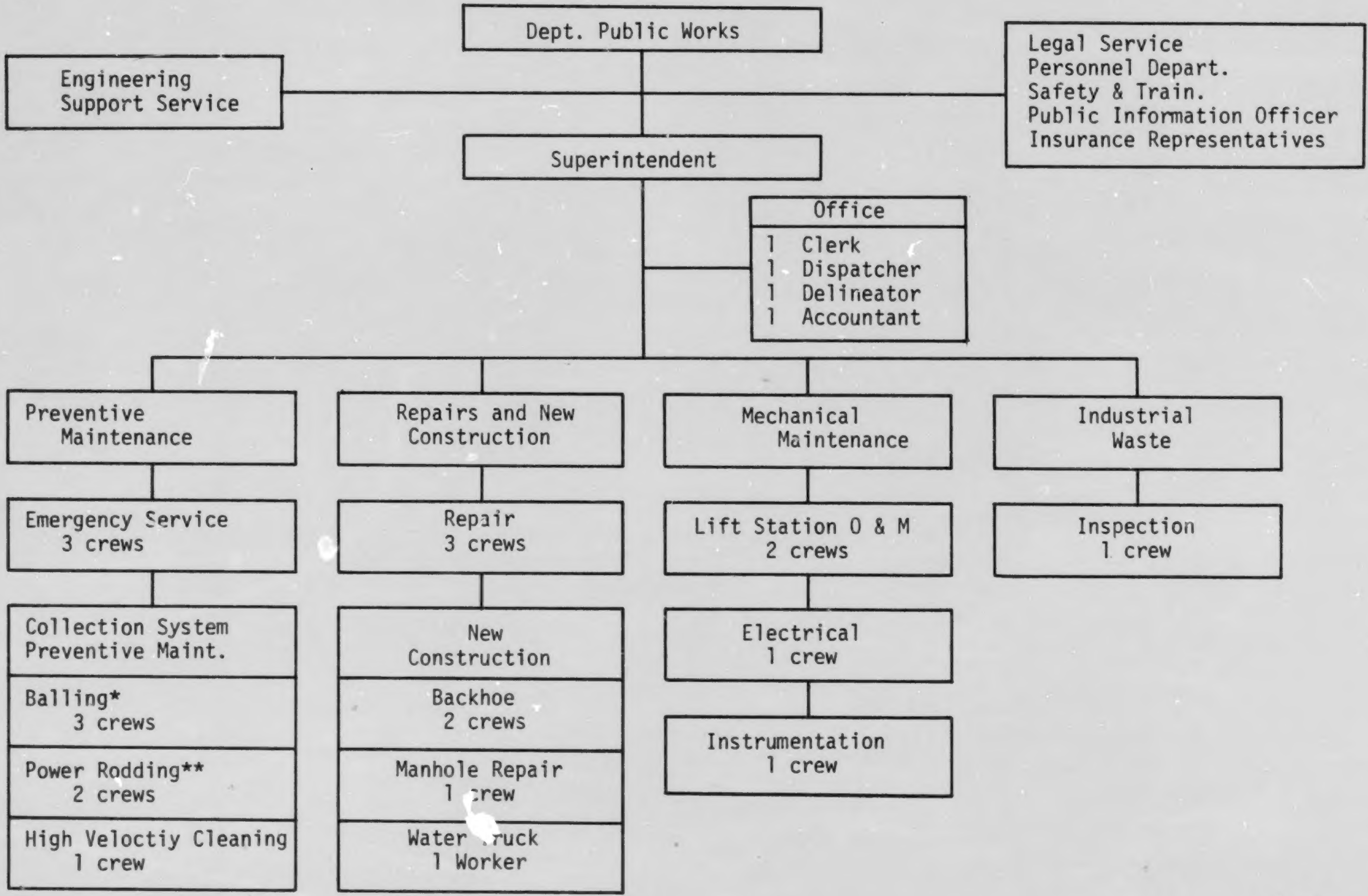
TABLE 11.7. ORGANIZATION OF CLEARWATER'S DIVISION OF WATER RECLAMATION


Dept. Public Works
Engineering Support Service
Legal Service
Personnel Depart.
Safety & Train.
Public Information Officer
Insurance Representatives
Superintendent
Office
1 Clerk
1 Dispatcher
1 Delineator
1 Accountant
Preventive Maintenance
Repairs and New Construction
Mechanical Maintenance
Industrial Waste
Emergency Service 3 crews
Repair 3 crews
Lift Station O & M 2 crews
Inspection 1 crew
Collection System Preventive Maint.
Balling* 3 crews
Power Rodding** 2 crews
High Veloctiy Cleaning 1 crew
New Construction
Backhoe 2 crews
Manhole Repair 1 crew
Water Truck 1 Worker
Electrical 1 crew
Instrumentation 1 crew

* Chemical Treatment

** Rented TV Inspection

11.92 Discussion of Clearwater's Organization

Clearwater's organization may not be similar to your organization. We hope that it may provide some insight to the problems and other factors that may affect the structure and function of a preventive maintenance and operations organization. There are many reasons to reduce or increase crew size and equipment use. Crew structure and cleaning methods may have to be changed to meet your responsibilities. Collecting good records and review and evaluation of effectiveness of equipment and programs will stimulate a need for developing standards and procedures for our profession that are needed today. We are past the time of claiming great production footages by various cleaning methods and to the point where we must answer the questions, "How well does your wastewater collection system perform its functions and what are the costs?"

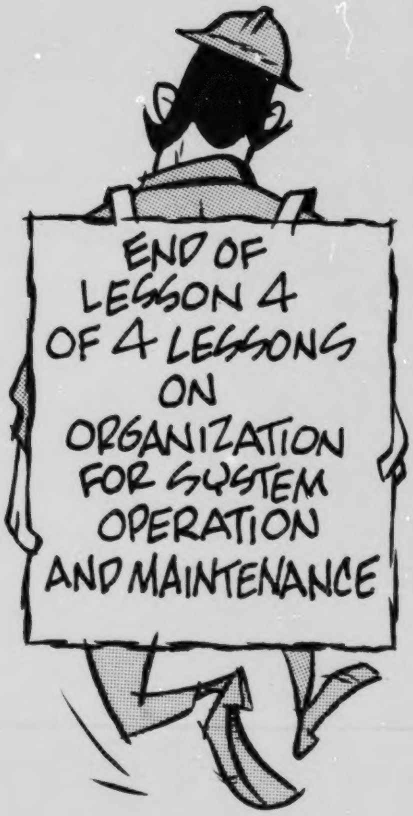
QUESTIONS

11.9A Will Clearwater's organization suit the needs of other agencies?

11.9B What questions must the wastewater collection profession answer today?

11.10 ADDITIONAL READING

1. Maintenance Management Systems for Municipal Wastewater Facilities, contract No. 68-01-0341, Municipal Operations Branch, Office of Water Program Operations, U.S. Environment Protection Agency, Washington, D.C. 20460, October, 1973. EPA-430/9-74-004. For sale by Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.60.


END OF
LESSON 4
OF 4 LESSONS
ON
ORGANIZATION
FOR SYSTEM
OPERATION
AND MAINTENANCE

DISCUSSION AND REVIEW QUESTIONS

Chapter 11. Organization for System Operation and Maintenance
(Lesson 4 of 4 Lessons)

Write the answers to these questions in your notebook before continuing with objective test on page 11-103. The problem numbering continues from Lesson 3.

18. Why do larger organizations have a special section or unit for lift station operation and mechanical maintenance?

19. How would you develop a work priority list for a lift station?

20. What kind of failures can occur in a lift station?

21. What are the tasks or jobs for an industrial waste section in a wastewater collection system agency?

22. How would you develop a work priority list for an industrial waste section?

23. What kind of equipment is needed by an industrial waste section?

24. How would you develop an organization to operate and maintain your wastewater collection system?

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SUGGESTED ANSWERS

Chapter 11. Organization for System Operation and Maintenance

11.0A The objectives of a modern wastewater collection system organization should be to do the following:

1. Minimize problems and service requests (complaints).
2. Be able to respond quickly to a service request, identify the source of the problem and correct the problem.
3. Have the taxpayers of the community know they are receiving a service.

11.0B Material in this manual can help existing wastewater collection system organizations by suggesting and encouraging the search for new and better ways to improve procedures to increase efficiency and reduce the cost of operating and maintaining wastewater collection systems.

11.1A Three critical factors that must be studied when developing the size and structure of a collection system organization include:

1. Responsibility of organization,
2. Size and condition of wastewater collection system, and
3. Existing and potential problems.

11.1B Collection system organizations could be responsible for for the following:

1. Main collection lines and laterals in streets and easement only.
2. Answer 1 plus building service lines up to property line.
3. Entire collection system up to the building foundation.

11.1C Agency A has the advantage of having responsibility only for that portion of the collection system in streets and easements. Access to the system is comparatively easy and special equipment for four-inch lines is not required.

Agencies B and C have better control over the system, especially with regard to workmanship and materials used to repair lines and install new services.

11.1D Factors related to size of community that influence the size and structure of the collection system organization include total area served, length and diameter of sewers, topography, total population served and population densities, types of industries, and seasonal loadings.

11.1E Features of a collection system other than sewers that influence size and structure of a collection system organization include operation and maintenance of lift stations, odor control facilities, siphons, "U" tubes and flow regulators. Locations of facilities and telemetering equipment are important, too. Whether the collection system is separate from or combined with storm water and the storm water system must be taken care of is critical also.

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11.1F Typical problem areas in many wastewater collection systems include:

1. Sections of old, deteriorated pipe
2. Roots
3. Inflow, infiltration and/or exfiltration
4. Grease
5. Grit and debris
6. Odors

11.1G Yes, an existing preventive maintenance program could over-perform and conduct activities more frequently than are needed to meet the agency's objectives.

11.1H The following questions must be answered regarding a sewer-use ordinance:

1. Who is responsible for monitoring and enforcement?
2. Who does the metering, sampling and inspection for billing?

11.2A Overflows, spills, or raw wastewater by-passes must be reported to:

1. Regional Water Pollution Control Agency
2. Local Health Department
3. Director of Public Works

11.2B Clearwater's Superintendent is responsible for planning and implementing maintenance, operation, training, and safety aspects of his section.

11.2C Items to be considered when summarizing a wastewater collection system include:

1. Total length of pipe and length of service lines and lines of different diameters,
2. Lift stations,
3. Condition of system,
4. Problem areas in system.

11.2D Items to be considered when summarizing the needs of a wastewater collection system include equipment and staffing to handle:

1. Emergency calls,
2. Preventive maintenance program,
3. Corrective maintenance program,
4. New construction,
5. Office/management.

11.2E Before attempting to review or develop the function and structure of each unit within the agency, the Superintendent should review policy, responsibilities, objectives, and the existing collection system and its needs.

11.3A Priority responses to requests for emergency services are as follows:

1. Manhole overflowing,
2. Flooded home or business,
3. Manhole cover off,
4. Cleanout overflowing,
5. Home service backed up.

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11.3B When multiple emergency calls are received, the field supervisor evaluates the problems, assigns priorities, redirects service crews and requests assistance from field preventive maintenance crews for specific equipment or assistance in handling calls as necessary.

11.3C When a private home becomes flooded with wastewater, try to remove the cause of flooding and assist the people living in the home to clean and remove articles which may have been damaged or will be damaged if left in place.

11.3D To minimize legal problems resulting from flooding:

1. Find cause and location of back up to identify who is responsible, and
2. Follow procedures approved by legal department.
3. Act quickly to reduce damages.

11.3E Flooding problems resulting from a low service connection can be corrected by installing and maintaining a backflow preventer and an overflow valve.

11.3F Service requests to recover valuable property from a sewer may be handled by a preventive maintenance crew; however, responses to such requests should be covered by agency policy.

11.3G All service requests and complaints must be investigated by a field supervisor.

11.3H A limitation of having a field supervisor investigate emergencies is that it may delay the arrival of the emergency crew at the problem area.

11.3I Advantages of having a field supervisor investigate emergencies include the following:

1. On-the-spot evaluation of problem.
2. Selection of a solution and procedure to solve the problem by an experienced supervisor.
3. Contact with the public by an experienced supervisor who is responsible for decision making and policy enforcement.
4. Keeps the supervisor in contact with the crews.

11.3J When there are no emergencies, the emergency service crew can collect and verify essential data, such as, map verification, services connected, and examine condition of collection system.

11.3K There are usually two workers on an emergency service crew. An additional person is required if someone has to enter a manhole.

11.3L Enroute to a problem area the crew begins to fill out a service request form. Upon arrival, the dispatcher is informed of time of arrival and location of unit.

11.3M The location of a main line stoppage is determined by inspecting manholes in a downstream flow direction until a manhole is located with reduced flow or no flow. The stoppage is located between this manhole and the next upstream manhole.

11.3N Stoppages are usually removed by using hand tools. If this procedure fails, power equipment such as a high velocity cleaner or a power rodder is used.

11.3O The first job a crew does upon arrival to clear a service line stoppage is to inspect the main line to be sure it is open and flowing.

11.3P A service line blockage is cleared by removing the cleanout cover and running a hand rod with a 2 or 3 1/2-inch auger down the cleanout to the main line. If this doesn't work, the problem is the resident's. If there is no cleanout, the resident should have a plumber inspect the line. If it is the agency's problem, the line will have to be dug up.

11.3Q After clearing a service line that had to be dug up, the Service Request Form and Repair Request Card must be completed.

11.3R If a new cleanout is required, it should be installed by the corrective maintenance repair crew.

11.3S The Superintendent believes three emergency service request crews are necessary.

11.3T The emergency service unit is given a special designation for the sake of dispatchers unfamiliar with the emergency crews and so all records can easily identify a service request handled during off duty hours.

11.4A Apparently, the greatest problem of Clearwater's preventive maintenance program was that it was not reducing the number of stoppages or service requests (complaints). The probable causes of this were that the condition of the system is unknown and the crews needed special training on how to use the available equipment.

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11.4B The condition of a wastewater collection system can be observed and determined by the use of a closed circuit television unit.

11.4C Advantages of video TV include:

1. Showing condition of collection system to Director of Public Works, staff engineers and other crews.
2. Locating and identifying problems.
3. Confirming or changing evaluation techniques to identify causes of stoppages.
4. Permitting supervisors to see and evaluate effectiveness of power cleaning equipment.
5. Evaluating effectiveness of TV unit.

11.4D A section of clear pipe is a helpful training facility because crews can observe the effectiveness of the cleaning equipment, its limitations, and how to use it as efficiently as possible.

11.4E The various types of equipment used to clean wastewater collection lines were listed so the Superintendent could compare methods available to solve problems.

11.4F Unfortunately no; each collection line problem must be identified as to probable cause and the proper piece of equipment selected to solve the problem.

11.4G A priority list should be developed for scheduling work by preventive maintenance crews to provide an organized approach to solving problems and insuring the completion of necessary jobs.

11.4H Clearwater developed the following priority list:

1. Assist emergency service crews.
2. Clean lines where stoppages occur within three days after the stoppage has been cleared.
3. Schedule power rodder in root problem areas to minimize root stoppages.
4. Schedule high velocity cleaner in grease problem areas to minimize grease stoppages.
5. Assign cleaning to areas of collection system to be cleaned this year.

11.4I During the preparation and scheduling of a chemical treatment program for root control, you should:

1. Review research literature.
2. Visit communities with similar problems and evaluate their root control programs.
3. Select two methods and field test in advance of full-scale root control program.
4. Keep records of all aspects of program.

11.4J Crews in Clearwater's Preventive Maintenance Units:

Crew	Number
Balling	3
Power Rodder	2
High Velocity Cleaner	1
Total	6 crews

11.4K Collection system workers in Preventive Maintenance Units:

Job Title	Number
Assistant Collection System Sup.	2
Collection System Repairman	6
Assistant Coll. System Repairman	10
TV System Operator	1
	19 workers

11.5A Items to be considered when trying to decide whether an agency should do a repair or new construction job or a private contractor should do the work include:

1. Cost of materials,
2. Time to complete job,
3. Special safety or construction equipment required.

11.5B The difference between the two units is that one does mainly repair work requiring hand tools in easements, and the other does new and repair work in open areas where mechanical equipment such as backhoes may be used.

11.5C Priority designations given repair work are (1) immediate repair, and (2) repair when time available.

11.5D Work orders for new construction come from requests by emergency service and preventive maintenance crews and from permits issued by the agency.

11.5E Closed circuit television inspection will reveal repair work consisting of the following:

1. Bad taps,
2. Bad joints,
3. Offset joints,
4. Broken pipes,
5. Deteriorated pipe.

11.5F Small, expensive hand tools should be kept in locked compartments in trucks.

11.6A Work priorities for Clearwater's lift station operation and mechanical maintenance section are as follows:

1. Respond to lift staion failures.
2. Assist other sections set up emergency pumps to prevent flooding and by-passes.
3. Respond to alarms from telemetered system.
4. Perform regular lift station maintenance.
5. Perform work on preventive maintenance schedule and work requests from other sections.
6. Evaluate and establish a program that will change lift station inspections from daily to monthly.

11.6B Clearwater can convert lift station visits from daily to monthly by establishing a preventive maintenance program, a telemetering system, and increasing the capacity of lift station auxiliary units such as oilers and reservoirs to operate for one month without service.

11.6C The major causes of lift station pump failures include malfunctions in the electrical or mechanical systems, or by debris in the wastewater being pumped, plugging an impeller or jamming a check valve.

11.6D An electrical failure may be the result of a power failure or an outside power source being switched off due to circuit overload on the main power source.

11.6E Repair work on an electrical system may be attempted only if you are qualified and authorized to do the work.

11.7A Clearwater formed an Industrial Waste Section to enforce the Sewer-use Ordinance and to collect information for charges to industrial waste dischargers.

11.7B The priority work list for Clearwater's Industrial Waste Section is as follows:

1. Inspect and monitor discharges for violations of Sewer-use Ordinance.
2. Monitor discharges for monthly sewer-use charges.
3. Locate sources of reported dumpings or by-passes.
4. Collect samples and deliver to lab for analysis.
5. Provide assistance for special studies.

11.8A Portable equipment must be readily available for all crews when they need it for jobs throughout the service area.

11.8B Useful pieces of portable equipment include air compressors, gasoline powered wastewater pumps, small portable generators, blowers, and two-way portable telephone or radio units.

11.9A Clearwater's organization is not intended to meet the needs of other agencies, but is presented to illustrate the procedure to follow to develop a wastewater collection system operation and maintenance division.

11.9B The wastewater collection profession must be able to answer the questions, "How well does your wastewater collection system perform its functions, and what are the costs?"

OBJECTIVE TEST

CHAPTER 11. ORGANIZATION FOR SYSTEM OPERATION AND MAINTENANCE

Please mark correct answers on answer sheet as directed at the end of Chapter 1. There may be more than one correct answer to each question.

1. Objectives of a modern wastewater collection system organization could include:

    1. Minimize unnecessary expenditures.
    2. Minimize odor complaints.
    3. Solve unemployment problems in the community.
    4. Minimize number of stoppages per mile of sewer.
    5. Ability to respond quickly to an emergency service request and provide the necessary service.

2. Some critical factors that should be considered when developing the structure of a wastewater collection system agency include:

    1. Responsibility of agency.
    2. How to keep the power rodder operating everyday.
    3. Size of wastewater collection system.
    4. Need for an above ground clear plastic pipe training facility.
    5. Existing and potential problems.

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3. Potential problems in a wastewater collection system include:
    1. Old, deteriorated pipe.
    2. Odors.
    3. Roots.
    4. Inflow, infiltration and/or exfiltration.
    5. Grease.

4. A sewer-use ordinance should specify who does the
    1. Monitoring.
    2. Enforcement.
    3. Regular cleaning of the main lines.
    4. Regular repairing of broken pipe.
    5. Regular sealing of leaky joints.

5. Which of the following items should be included in an inventory of a wastewater collection system:
    1. Number of pump parts in warehouse.
    2. Estimate of sizes and lengths of sewers.
    3. Condition of collection system.
    4. Number of trucks.
    5. Safety statistics.

GO TO NEXT PAGE

6. Organization charts are helpful to show:

   1. How the collection system is organized.
   2. How to locate sewers.
   3. The chain of command of an agency.
   4. The structure of an agency.
   5. The way to select solutions to problems.

7. The advantages of having an emergency service crew supervisor inspect emergency service requests (complaints) include:

   1. On-the-spot evaluation of the problem by a supervisor.
   2. Selection of a solution and procedure to solve the problem by an experienced supervisor.
   3. Contact with the public by an experienced supervisor.
   4. Keeps supervisor in contact with crews.
   5. There are no advantages.

8. How does an emergency service crew try to remove a stoppage?

   1. Flushing.
   2. Balling.
   3. Tell home owner to stop dumping grease into sewer.
   4. Parachutes.
   5. Hand rods.

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9. How can a closed circuit television unit with video tape help to evaluate the condition of a wastewater collection system?

    1. Exact location and identification of problems can be determined.
    2. TV camera can remove stoppages.
    3. Effectiveness of cleaning techniques can be studied under various conditions in collection system.
    4. Service lines to homes can be inspected.
    5. Chemicals can be applied for root control.

10. What are the advantages of a training facility constructed of clear 6-inch plastic pipe above ground?

    1. Learn proper procedures for use of sewer line cleaning equipment.
    2. Observe cleaning equipment in action and evaluate its effectiveness and usefulness.
    3. See how material in a sewer is actually moved and removed by using different techniques of operating sewer cleaning equipment.
    4. Learn how to keep good records.
    5. Learn how to use sewer gas detection equipment.

11. Jobs done by preventive maintenance crews include:

    1. Assist emergency service crew clear difficult stoppages on request.
    2. Clean segments of sewers where stoppages were removed by emergency service crew.
    3. Clear areas with root or grease problems on a regular basis.
    4. Clean sewers frequently enough to prevent problems from developing.
    5. Change impellers on damaged pumps.

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12. Under what conditions might a private contractor be considered to do a sewer repair job?

    1. Material for job is costly.
    2. A long time is required to complete job.
    3. Special equipment is required.
    4. Required safety equipment is not available.
    5. Necessary crews are not avilable.

13. Lift station failures include:

    1. Failure to pump wet well dry after each pumping cycle.
    2. Electrical circuit failure.
    3. Controller failure.
    4. Odor failure.
    5. Pump failure.

14. Typical assigned duties of an industrial waste section include:

    1. Inspecting discharges into collection system.
    2. Balling sewers filled with grease from restaurants.
    3. Collecting samples of discharges into collection system.
    4. Attempting to locate and/or identify sources of wastes that upset wastewater treatment plants.
    5. Collecting data and making recommendations regarding industries that violate sewer-use ordinances.

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Review Questions

15. Hazards that a wastewater collection system worker could encounter on the job include:

    1. Poisonous or toxic gases.
    2. Explosive conditions.
    3. Excavation cave-ins.
    4. Electrical shock.
    5. Drowning.

16. Wastewater collection system workers can be protected from hazardous atmospheres in confined spaces by:

    1. Calibrating atmospheric testing equipment before testing the atmosphere.
    2. Testing for hazardous atmospheres before entering confined space.
    3. Continuously testing entire work area for hazardous atmospheres when working in confined spaces.
    4. Ventilating confined spaces before entry and continuously while working in confined space.
    5. Wearing a self-contained breathing apparatus if necessary, but never in an explosive atmosphere.

THE END

COLLECTION SYSTEM WORDS

by

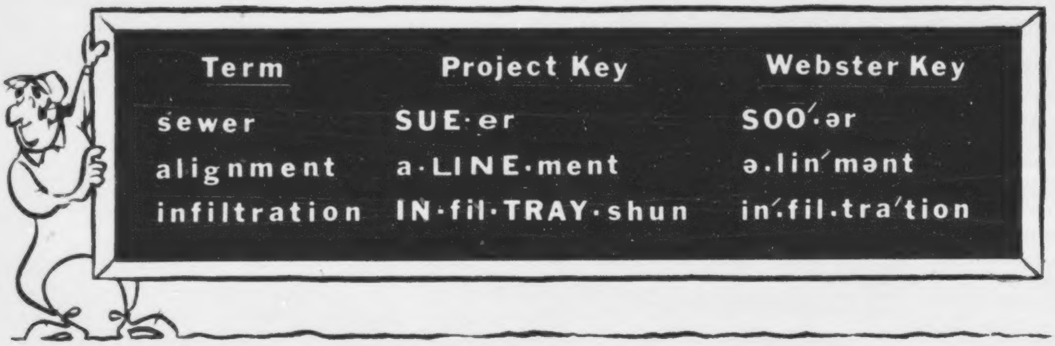
George Freeland

WORKER'S PROJECT PRONUNCIATION KEY

By Warren L. Prentice

The Worker's Project Pronunciation Key is designed to aid you in the pronunciation of new words. While this Key is based primarily on familiar sounds, it does not attempt to follow any particular pronunciation guide. This Key is designed solely to aid workers in this program.

You may find it helpful to refer to other available sources for pronunciation help. Each current standard dictionary contains a guide to its own pronunciation Key. Each Key will be different from each other and from this Key. Examples of the differences between the Key used in this program and the Webster's New World Dictionary Key, Second College Edition, 1972[1] are shown below:



Term	Project Key	Webster Key
sewer	SUE·er	SOO´·ər
alignment	a·LINE·ment	ə.lin´mənt
infiltration	IN·fil·TRAY·shun	in´.fil.tra´tion

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[1] The Webster's New World Dictionary, Second College Edition, 1972 was chosen rather than an unabridged dictionary because of its availability to most collection system workers.

In using this Key, you should accent (say louder) the syllable which appears in capital letters. The following chart is presented to give examples of how to pronounce words using the Worker's Project Key:

	Syllable			
	1st	2nd	3rd	4th
Word				
Sewer	SUE	er		
Alignment	a	LINE	ment	
Infiltration	IN	fil	TRAY	shun

The first word, sewer, has its first syllable accented. The second word, alignment, has its second syllable accented. The third word, infiltration, has its first and third syllables accented.

We hope you will find the Key useful in unlocking the pronunciation of any new word.

EXPLANATION OF WORDS

The meanings of words in the glossary of this manual are based on current usage by the wastewater collection profession and definitions given in Glossary-Water and Wastewater Control Engineering, prepared by the Joint Editorial Board representing APHA, ASCE, AWWA and WPCF,* 1969. Certain words used by wastewater collection system workers tend to have slightly different meanings in some regions of the United States. We have tried to standardize word meanings as much as possible.

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*APHA.	American Public Health Association.
ASCE.	American Society of Civil Engineers.
AWWA.	American Water Works Association.
WPCF.	Water Pollution Control Federation.

GLOSSARY

ABANDONED (a-BAN-dund) ABANDONED

A length, section or portion of a collection system no longer in service and left in place, underground. A typical example is where a house or building is razed or removed with the building service connection left open and unused.

ABATEMENT (a-BAIT-ment) ABATEMENT

The correction of or termination of an undesirable or unlawful condition affecting the wastewater collection system. A property owner found to have inflow sources connected to the collection system may be issued a "NOTICE OF ABATEMENT". Such notices will usually describe the violation, suggest corrective measures and grant a period of time for compliance.

ABSORPTION (ab-SORP-shun) ABSORPTION

The taking up of one substance into the body of another, such as liquid saturating a solid material. Solids in this use are types of soil, such as gravel, sand and gravel, sand, loam or clay.

ABSORPTION CAPACITY ABSORPTION CAPACITY

The amount of liquid which a solid material can absorb. Sand, as an example, can hold approximately one third of its volume in water, or three cubic feet of dry sand can contain one cubic foot of water. A denser soil, such as clay, can hold much less water and thus has a lower absorption capacity.

ABSORPTION RATE ABSORPTION RATE

The speed that a solid can absorb a liquid. Under a head, water can infiltrate a given volume of gravel very rapidly, will take more time with sand for the same volume and a comparably much longer time to saturate the same quantity of clay.

AEROBIC (AIR-O-bick) AEROBIC

A condition in which "free" or dissolved oxygen is present in the aquatic (water) environment. If no dissolved oxygen is present, anaerobic conditions exist.

AIR BLOWER AIR BLOWER

A device used to ventilate manholes and lift stations.

AIR TEST AIR TEST

A method of inspecting a sewer pipe for leaks. Inflatable or similar plugs are placed in the line and the space between these plugs is pressurized with air. A drop in pressure indicates the line or run being tested has leaks.

AIR TEST, QUICK AIR TEST, QUICK

(See 'QUICK AIR TEST')

ALIGNMENT (a-LINE-ment) ALIGNMENT

Line. Location and direction of a pipeline or other line.

ALLUVIAL DEPOSIT (a-LOU-vee-al) **ALLUVIAL DEPOSIT**

Sediment deposited in place by the action of streams.

ALTERNATING CURRENT (A.C.) **ALTERNATING CURRENT**

Periodic electrical current which has alternating positive and negative values.

AMBIENT (AM-bee-ent) **AMBIENT**

Surrounding. Ambient or surrounding atmosphere.

AMPERAGE **AMPERAGE**

The strength of an electric current measured in amperes.

AMPERE **AMPERE**

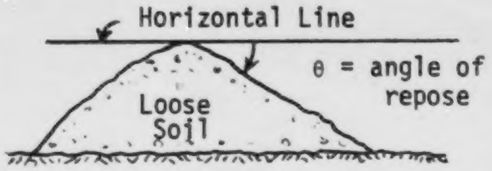
The unit used to measure current strength. The current produced by an electromotive force of one volt acting through a resistance of one ohm.

ANAEROBIC (AN-air-O-bick) **ANAEROBIC**

Decomposition and decay of organic material in an aquatic (water) environment containing no "free" or dissolved oxygen. If dissolved oxygen is present, aerobic conditions exist.

ANGLE OF REPOSE **ANGLE OF REPOSE**

The angle between a horizontal line and the slope or surface of unsupported material such as gravel, sand, or loose soil. Also called the natural slope.



ANIMAL WASTES ANIMAL WASTES

(1) Urine and fecal wastes of living animals.

(2) Wastes of animal tissue from meat processing (feathers included), hospital, surgical and clinical facility wastes of animal types.

(3) Similar to (2) above, but cooked or prepared wastes of animal tissues and bones from domestic or commercial food preparation.

ANNULAR SPACE (AN-ul-are) ANNULAR SPACE

A ring-shaped space. For example, the space between the cutout section of a pipe liner and the manhole trough.

ANOXIC ANOXIC

Oxygen deficient.

APARTMENT COMPLEX APARTMENT COMPLEX

One or more buildings at a single location, each having accommodations and domestic facilities for family occupation as residences. An apartment building may contain several residences with a single connection to the wastewater collection system. A complex can have several buildings with a single connection.

APPURTENANCE (a-PURR-ten-nans) APPURTENANCE

Machinery, appliances, structures and other parts of the main structure necessary to allow it to operate as intended, but not considered part of the main structure.

AQUIFER (ACK-wi-fer) AQUIFER

A porous, water bearing geologic formation. Generally restricted to materials capable of yielding an appreciable supply of water.

ARCH ARCH

The curved top of a sewer pipe or conduit.

ARTIFICIAL GROUND WATER TABLE ARTIFICIAL GROUND WATER TABLE

A ground water table that is affected by artificial means. Examples of activities that artificially raise the level of a ground water table include agricultural irrigation, dams and excessive sewer line exfiltration. A ground water table can be artificially lowered by sewer line infiltration, water wells, and similar drainage methods.

ASPHYXIATION (ass-FIX-i-ā-shun) ASPHYXIATION

An extreme condition often resulting in death due to a lack of oxygen and excess carbon dioxide in the blood from any cause. Also called suffocation.

AUGER (AW-grr) AUGER

A sharp tool used to go through and break up or remove various materials that become lodged in sewers.

BACKFILL BACKFILL

(1) Material used to fill in a trench or excavation.

(2) The act of filling a trench or excavation, usually after a pipe or some type of structure has been placed in the trench or excavation.

BACKFILL, BORROW BACKFILL, BORROW

(See 'BORROW')

BACKFILL COMPACTION BACKFILL COMPACTION

(1) Tamping, rolling or otherwise mechanically compressing material used as backfill for a trench or excavation to achieve density or solidarity adequate to support predicted loads after the material is in place in the excavation.

(2) Compaction of a backfill material can be expressed in a percentage of the maximum compactability, density or load capacity of the material being used.

BACKFILL, SELECT BACKFILL, SELECT

(See, 'SELECT BACKFILL')

BACKFLUSHING BACKFLUSHING

A procedure used to wash settled waste matter off upstream structures to prevent odors from developing after a main line stoppage has been cleared.

BACKHOE BACKHOE

An excavating machine that has the bucket rigidly attached to a hinged stick on the boom and is drawn toward the machine during excavation.

BACKWATER GATE BACKWATER GATE

A gate installed at the end of a drain or outlet pipe to prevent the backward flow of water or wastewater. Generally used on sewer outlets into streams to prevent backward flow during times of flood or high tide. Also called a TIDE GATE.

BACTERIA (back-TEAR-e-ah) BACTERIA

Bacteria are living organisms, microscopic in size, which consist of single cells. Most bacteria use organic matter for their food and produce waste products as a result of their life processes.

BALLING BALLING

A method of hydraulically cleaning a sewer or storm drain by using the pressure of a water head to create a high cleansing velocity of water around the ball. Normal operation provides for the ball to be restrained by a cable while water is allowed to wash past the ball at high velocity. Special sewer cleaning balls have an outside tread that causes them to spin or rotate, resulting in a 'scrubbing' action of the flowing water along the pipe wall.

BAR RACK BAR RACK

A screen composed of parallel bars, either vertical or inclined, placed in a sewer or other waterway to catch debris. The screenings may be raked from it.

BARREL BARREL

(1) The cylindrical part of a pipe that may have a bell on one end.

(2) The cylindrical part of a manhole between the cone at the top and the shelf at the bottom.

BEDDING BEDDING

The prepared base or bottom of a trench or excavation on which a pipe or other underground structure is supported.

BEDDING COMPACTION BEDDING COMPACTION

(1) Tamping, rolling or otherwise mechanically compressing material used as bedding for a pipe or other underground structure to a density or solidarity adequate to support predicted loads.

(2) Bedding compaction can be expressed in a percentage of the maximum load capacity of the bedding material at maximum capacity.

(3) Bedding compaction also can be expressed in load capacity of pounds per square foot.

BEDDING DESTRUCTION BEDDING DESTRUCTION

Loss of grade, load capacity or material of a bedding.

BEDDING DISPLACEMENT BEDDING DISPLACEMENT

Bedding which has been removed after placement and compaction. In a sewer pipe system, this can take place as a result of washouts due to infiltration, earth shifts or slides, damage from adjacent excavations and/or improper backfill methods.

BEDDING FAULTS BEDDING FAULTS

Locations where bedding was improperly applied and thus failed.

BEDDING GRADE BEDDING GRADE

(1) In a gravity flow sewer system, pipe bedding is constructed and compacted to the design grade of the pipe. This is usually expressed in a percentage, such as 0.5% grade would be a drop of one-half foot per hundred feet of pipe.

(2) Bedding grade for a gravity flow sewer pipe also can be specified by indications of elevation above mean sea level at specific points.

BEDDING, MANHOLE

BEDDING, MANHOLE

(See 'MANHOLE BEDDING')

BEDDING MATERIAL, SELECT

BEDDING MATERIAL, SELECT

(See 'SELECT BEDDING')

BELL

BELL

(1) In pipe fitting, the recessed overenlarged female end of a pipe into which the male end fits. Also called a hub.

(2) In plumbing, the expanded female end of a wiped joint.

BELL-AND-SPIGOT JOINT

BELL-AND-SPIGOT JOINT

A form of joint used on pipes which have an enlarged diameter or bell at one end, and a spigot at the other which fits into and is laid in the bell. The joint is then made tight by lead, cement, rubber "O" ring, or other jointing compounds or materials.

BELLMOUTH

BELLMOUTH

An expanding, rounded entrance to a pipe or orifice.

BEND

BEND

A piece of pipe bent or cast into an angular shape.

BIOCHEMICAL OXYGEN DEMAND

BIOCHEMICAL OXYGEN DEMAND

The BOD indicates the rate of oxygen used by wastewater under controlled conditions of temperature and time (20°C and 5 days). The BOD test is sometimes used to indicate the strength of wastewater.

BIT BIT

(1) Cutting blade used in rodding operations.

(2) Cutting teeth on the auger head of a sewer boring tool.

BLOCKAGE BLOCKAGE

(1) When a collection system becomes plugged and the flow backs up, it is said to have a "blockage".

(2) The place and cause of a blockage. Example: "Fifty-one feet from a specific manhole" and "a grease blockage".

(3) Partial or complete interruption of flow as a result of some obstruction in a sewer.

Commonly called STOPPAGE.

BLOWER BLOWER

A device used to ventilate manholes and lift stations.

BLUEPRINT BLUEPRINT

A photographic print in white on a bright blue background used for copying maps, mechanical drawings, construction plans and architects' plans.

BOD (BEE-OH-DEE) BOD

Initials for "Biochemical Oxygen Demand". The BOD indicates the rate of oxygen used by wastewater under controlled conditions of temperature and time (20° and 5 days). The BOD test is sometimes used to indicate the strength of wastewater.

BORROW BACKFILL BORROW BACKFILL

Material used for backfilling a trench or excavation which was not the original material removed during excavation. This is a common practice where tests on the original material show it to have poor compactability or load capacity. Also called 'IMPORTED BACKFILL'.

BRACES BRACES

(See 'CROSS BRACES')

BRANCH MANHOLE BRANCH MANHOLE

A sewer or drain manhole which has more than one pipe feeding into it. A standard manhole will have one outlet and one inlet. A branch manhole will have one outlet and two or more inlets.

BRANCH SEWER BRANCH SEWER

A sewer that receives wastewater from a relatively small area and discharges into a main sewer serving more than one branch-sewer area.

BREAK BREAK

A fracture or opening in a pipe, manhole or other structure due to structural failure and/or structural defect.

BRICKWORK BRICKWORK

A structure made of brick, such as in older sewers.

BROKEN HUB BROKEN HUB

In bell and spigot pipe, the bell portion is frequently called the 'hub'. A fracture or break in the bell portion is thus called a broken hub.

BROKEN SECTION BROKEN SECTION

A run of pipe between two joints is referred to as a 'section'. A fracture in a section is called a broken section.

BUCKET BUCKET

(1) A special device designed to be pulled along a sewer for the removal of debris from the sewer. The bucket has one end open with the opposite end having a set of jaws. When pulled from the jaw end, the jaws are automatically opened. When pulled from the other end, the jaws close. In operation, the bucket is pulled into the debris from the jaw end and to a point where some of the debris has been forced into the bucket. The bucket is then pulled out of the sewer from the other end, causing the jaws to close and retain the debris. Once removed from the manhole, the bucket is emptied and the process repeated.

(2) A conventional bail is used in 'bucketting out'.

BUCKET BAIL BUCKET BAIL

The pulling handle on a bucket machine.

BUCKET MACHINE BUCKET MACHINE

A powered winch machine designed for operation over a manhole and controlling the travel of buckets used to clean sewers.

BUCKETTING OUT BUCKETTING OUT

An expression used to cover removal of debris from a manhole with a pail on a rope. In balling or high velocity cleaning of sewers, debris is washed into the downstream manhole. Removal of this debris by scooping it into pails and hauling debris out is termed 'bucketting out'.

BUILDING SERVICE BUILDING SERVICE

A saddle or "Y" connection to a lateral or branch sewer for connection of a building lateral.

BUILDING SEWER BUILDING SEWER

A gravity flow pipeline connecting a building wastewater collection system to a lateral or branch sewer. The building sewer may begin at the outside of the building's foundation wall or some distance (such as 2 to 10 feet) from the wall, depending on local sewer ordinances. Also called a HOUSE CONNECTION or a SERVICE CONNECTION.

BUILDING WASTEWATER COLLECTION SYSTEM BUILDING WASTEWATER COLLECTION SYSTEM

All of the wastewater drain pipes and their hardware that connect plumbing fixtures inside or adjacent to a building to the building sewers. This includes traps, vents and clean-outs.

BY-PASS BY-PASS

A pipe, valve, gate, weir, trench or other device designed to permit all or part of a wastewater flow to be diverted from usual channels of flow. Sometimes refers to a special line to permit conveying flow around a facility or device that needs maintenance or repair.

BY-PASSING BY-PASSING

The act of causing all or part of a flow to be diverted from its usual channels. In a wastewater treatment plant, overload flows should be by-passed into a holding pond for future treatment.

C-ZONED C-ZONED

An area set aside for commercial use.

CAPILLARY EFFECT (CAP-i-larry) CAPILLARY EFFECT

Also called "Wicking Effect". The ability of a liquid to rise above an established level to saturate a porous solid.

CATCH BASIN CATCH BASIN

A chamber or well used with storm or combined sewers as a means of removing grit which might otherwise enter and be deposited in sewers. Also see 'STORM-WATER INLET' and 'CURB INLET'.

CAULK (KAWK) CAULK

To stop up and make watertight the joints of a pipe by filling the joints with a waterproof compound or material.

CAULKING (KAWK-ing) CAULKING

(1) A waterproof compound or material used to fill a pipe joint.

(2) The act of using a waterproof compound or material to fill a pipe joint.

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CAVITATION (CAV-i-TAY-shun) CAVITATION

The formation and collapse of a gas pocket or bubble on the blade of an impeller. The collapse of this gas pocket or bubble drives water into the impeller with a terrific force that can cause pitting on the impeller surface.

CENTRIFUGAL PUMP CENTRIFUGAL PUMP

A pump consisting of an impeller fixed on a rotating shaft and enclosed in a casing, and having an inlet and a discharge connection. The rotating impeller creates pressure in the liquid by the velocity derived from centrifugal force.

CESSPOOL CESSPOOL

A lined or partially lined excavation or pit for dumping raw household wastewater for natural decomposition and percolation into the soil.

CFS CFS

Initials for "Cubic Feet per Second", a measure of flow rate.

CHECK VALVE CHECK VALVE

A special valve with a disc or flap which has a hinge on one edge so that it opens in the direction of normal flow and is forced shut when flows attempt to go in the reverse or opposite direction of normal flows.

CHEMICAL GROUT CHEMICAL GROUT

Two chemical solutions that form a solid when combined. Solidification time is controlled by the strength of the mixtures used and the temperature.

CHEMICAL GROUTING | CHEMICAL GROUTING

Sealing leaks in a pipeline or manhole structure by injection of chemical grout. In pipelines, the chemicals are injected through a device called a 'packer'. In operation, the packer is located at the leak point with the use of a television camera. Inflatable boots at either end of the packer isolate the leak point and the grouting chemicals are then forced into the leak under pressure. When sufficient time for solidification of the grout has passed, the packer is deflated and moved to the next location.

CIRCUIT | CIRCUIT

The complete path of an electric current, including the generating apparatus or other source, or a specific segment or section of the complete path.

CIRCUIT BREAKER | CIRCUIT BREAKER

A safety device in an electrical circuit that automatically shuts off the circuit when it becomes overloaded. Device can be manually reset.

CHLORINATOR | CHLORINATOR

A device used to regulate the transfer of chlorine from a container to flowing wastewater for such purposes as odor control and disinfection.

CLEANING, PIPE | CLEANING, PIPE

(See 'PIPE CLEANING')

CLEANOUT | CLEANOUT

A point of access to a wastewater collection system for insertion of tools, rods or snakes to effect pipeline cleaning.

CLEANOUT, TWO-WAY CLEANOUT, TWO-WAY

A cleanout designed for rodding or working a snake into a pipe in either direction. Most often application is in building lateral pipes at or near a property line.

CLINICAL LABORATORY CLINICAL LABORATORY

A special medical facility devoted to the identification of diseases and ailments through tests, studies and culture growths of symptomatic and pathological tissue samples. Of significance to a sewer system because of possible accidental or intentional release of highly contagious and/or infectious wastes.

COAGULATE (co-AGG-you-late) COAGULATE

The destabilization, aggregation and binding together of colloids and emulsions.

COHESIVE (coe-HE-sive) COHESIVE

Tending to stick together.

COLLAPSED PIPE COLLAPSED PIPE

A pipe that has one or more points in its length which have been crushed or partially crushed by exterior pressures or impacts.

COLLECTION MAIN COLLECTION MAIN

A collection pipe to which building laterals are connected.

COLLECTION SYSTEM COLLECTION SYSTEM

A network of pipes, manholes, cleanouts, traps, siphons, lift stations and other required structures to effect collection of all wastewater and wastewater carried wastes of an area and transportation to a treatment plant or disposal system. The collection system includes land, wastewater lines and appurtenances, pumping stations and general property.

COLLOIDS (KOL-loids) COLLOIDS

Very small solids (particulate or insoluble material) in a finely divided form that remain dispersed in a liquid for a long time due to their small size and electrical charge.

COMBINED SEWER COMBINED SEWER

A sewer intended to receive both wastewater and storm or surface water.

COMBINED SYSTEM COMBINED SYSTEM

A wastewater collection system intended to collect both sanitary wastewaters and storm or surface water runoff.

COMBINED WASTEWATER COMBINED WASTEWATER

A mixture of surface runoff and other wastewater such as domestic or industrial wastewater.

COMMERCIAL CONTRIBUTION COMMERCIAL CONTRIBUTION

Liquid and liquid carried wastes generated by commercial establishments and dumped into the wastewater collection system. Used in this context, commercial contributions are distinct from domestic and industrial sources of wastewater contributions. Examples of high yield commercial sources are laundries, restaurants and hotels.

COMMERCIAL TELEVISION QUALITY COMMERCIAL TELEVISION QUALITY

Refers to television levels of picture quality. Commercial television pictures are considered to have resolutions between 350 and 525 lines. This is higher quality than surveillance quality and lower quality than inspection quality pictures.

COMMINUTOR (com-min-OO-ter) COMMINUTOR

A device used to reduce the size of solid chunks in wastewater by shredding (comminuting). The shredding action can be visualized if you imagine many scissors cutting or hammering to shreds all the large solids in the wastewater.

COMPACTED BACKFILL COMPACTED BACKFILL

(See 'BACKFILL COMPACTION')

COMPACTED BEDDING COMPACTED BEDDING

(See 'BEDDING COMPACTION')

COMPACTION COMPACTION

Tamping or rolling of a material to achieve a surface or density that is able to support predicted loads.

COMPACTION TEST COMPACTION TEST

Any method of determining the weight a compacted material is able to support without damage or displacement. Usually stated in pounds per square foot.

COMPUTED CONTRIBUTION COMPUTED CONTRIBUTION

A liquid or liquid carried contribution to a collection system that is computed on the basis of expected discharges from all of the sources as opposed to actual measurement or metering.

COMPUTED COMMERCIAL CONTRIBUTION COMPUTED COMMERCIAL CONTRIBUTION

That part of a collection system flow computed to originate in the commercial establishments on the basis of expected flows from all commercial sources.

COMPUTED DOMESTIC CONTRIBUTION COMPUTED DOMESTIC CONTRIBUTION

That part of a collection system flow computed to originate in the residential or domestic occupancy facilities based on the flow contribution from each person.

COMPUTED FACILITY CONTRIBUTION COMPUTED FACILITY CONTRIBUTION

The computed liquid waste discharge from a single facility based on the sources of waste flows in the facility.

COMPUTED INDUSTRIAL CONTRIBUTION COMPUTED INDUSTRIAL CONTRIBUTION

The computed liquid waste discharge from industrial operations based on the expected discharges from all sources.

COMPUTED PER CAPITA CONTRIBUTION COMPUTED PER CAPITA CONTRIBUTION

The computed wastewater contribution from a domestic area, based on the population of the area. In the United States, the daily average wastewater contribution is considered to be 100 gallons per capita per day (100 gpcd).

COMPUTED TOTAL CONTRIBUTION

COMPUTED TOTAL CONTRIBUTION

The total anticipated load on a wastewater treatment plant or the total anticipated flow in any collection system area based on the combined computed contributions of all connections to the system.

COMPUTED COLLECTION SYSTEM CONTRIBUTION

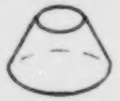
COMPUTED COLLECTION SYSTEM CONTRIBUTION

That part of a collection system flow computed to be actual domestic and industrial wastewater. Applied to infiltration/inflow research, the computed domestic and industrial wastewater contribution is subtracted from a total flow to determine infiltration/inflow amounts.

CONCENTRIC MANHOLE CONE

CONCENTRIC MANHOLE CONE

Cone tapers uniformly from barrel to manhole cover.



CONCRETE CRADLE

CONCRETE CRADLE

A device made of concrete that supports sewer pipe.

CONDUCTOR

CONDUCTOR

(1) A pipe which carries a liquid load from one point to another point. In a wastewater collection system, a conductor is often deemed to be a large size pipe with no service connections. Also called a 'conduit', 'monitor', 'interceptor' or 'inter-connector'.

(2) In plumbing, a line conducting water from the roof to the storm drain or other means of disposal. Also called a downspout.

(3) In electricity, a substance, body, device or wire that readily conducts or carries electricity.

CONDUIT CONDUIT

Any artificial or natural duct, either open or closed, for conveying liquids or possibly other fluids. An electrical conduit conveys electricity.

CONTAMINATION CONTAMINATION

Introduction into water of any microorganisms, chemicals, wastes, or wastewater in a concentration that makes the water unfit for its intended use.

CONTRIBUTION CONTRIBUTION

Waters, wastewaters or liquid carried wastes discharged or entering a wastewater collection system.

COULOMB COULOMB

A measurement of the amount of an electrical charge conveyed by an electric current of one ampere in one second. 1 coulomb equals about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons).

COUPLING COUPLING

(1) A threaded sleeve used to connect two pipes.

(2) A device used to connect two adjacent parts, such as a pipe coupling, hose coupling or drive coupling.

CROSS BRACES CROSS BRACES

Shoring members placed across a trench to hold other horizontal and vertical members in place.

CROSS CONNECTION CROSS CONNECTION

(1) A connection between a storm drain system and a sanitary collection system.

(2) Less frequently used, a connection between two sections of a collection system to handle anticipated overloads of one system.

(3) A connection through which a supply of potable water could be contaminated or polluted.

CURB INLET CURB INLET

A chamber or well built at the curbline of a street to admit gutter flow to the storm water drainage system. Also see 'STORM WATER INLET' and 'CATCH BASIN'.

CURRENT CURRENT

A movement or flow of electricity.

Water flowing in a pipe is measured in gallons per second past a certain point, not by the number of water molecules going past a point. Electric current is measured by the number of coulombs per second flowing past a certain point in a conductor. A coulomb is equal to about 6.25×10^{18} electrons (6,250,000,000,000,000,000 electrons). A flow of one coulomb per second is called 1 ampere, the unit of the rate of flow of current.

DATA-VIEW DATA-VIEW

A high speed reporting and recording system used with closed circuit pipeline television equipment. Data-view provides digital indexing of date, job number, footages and air test pressures in the television picture itself. Where video tape recordings of television pipe inspections or pipe sealing activities are made, data-view reports are automatically recorded on the taped pictures.

DEADEND MANHOLE DEADEND MANHOLE

A manhole located at the upstream end of a sewer and having no inlet pipe. Also called a 'TERMINAL MANHOLE.'

DEBRIS (de-BREE) DEBRIS

Any material in wastewater found floating, suspended or moving along the bottom of a sewer. This material may cause stoppages by getting hung up on roots or settling out in a sewer. Debris includes grit, paper, plastic, rubber, silt, and all materials except liquids.

DEBRIS, INFILTRATED DEBRIS, INFILTRATED

(See 'INFILTRATED DEBRIS')

DECOMPOSED PIPE DECOMPOSED PIPE

Pipe which has been destroyed or had portions of it weakened by chemical actions.

DECOMPOSITION, DECAY DECOMPOSITION, DECAY

When organic matter breaksdown into simpler substances under anaerobic conditions (putrefaction) such as in most collection lines, undesirable odors are produced. Generally aerobic processes convert unstable materials into more stable forms by chemical or biological action. Waste treatment encourages decay in a controlled situation in order that the material may be disposed of in a stable form. In aerobic decomposition processes, the odors are much less objectionable than those produced by anaerobic decomposition.

DEFECT DEFECT

A point where a pipe or system structure has sustained damage or has a fault.

DEFECT, SURFACED DEFECT, SURFACED

(See 'SURFACED DEFECT')

DEFLECTED DEFLECTED

(1) Pipe which has been forced out of round by external pressures. Mainly applicable to fiber and plastic pipes where backfill compaction has resulted in unequal pressures on all sides of the pipe.

(2) Pipe whose direction has been changed either to the left, right, up, or down.

DEGRADATION (de-grah-DAY-shun) DEGRADATION

The conversion of a substance to simpler compounds. For example, the degradation of organic matter to carbon dioxide and water.

DESTROYED PIPE DESTROYED PIPE

Pipe which has been damaged, decomposed, deflected, crushed or collapsed to a point that it must be replaced.

DETENTION DETENTION

The delay or holding of the flow of water and water carried wastes in a pipe system. This can be due to a restriction in the pipe, a stoppage or a dip. Also the time water is held or stored in a basin or a wet well. This is also called 'RETENTION'.

DETRITUS (de-TRY-tus) DETRITUS

The heavy, coarse material carried by wastewater. Also called 'GRIT'.

DEWATER | DEWATER

To drain or remove water from an enclosure. A structure may be dewatered so that it can be inspected or repaired. Also draining or removing water from sludge to increase the solids concentration.

DIP | DIP

A point in a sewer pipe with a drain grade defect that results in a puddle of standing water when there is no flow. If the grade defect is severe enough to cause the standing water to fill the pipe at any point (preventing passage of air through the pipe), it is called a 'Trap Dip', 'Full Dip' or 'Filled Dip'.

DIRECT CURRENT (D.C.) | DIRECT CURRENT

Electrical current flowing in one direction only and essentially free from pulsation.

DISCHARGE HEAD | DISCHARGE HEAD

The pressure (in feet or pounds per square inch (psi)) on the discharge side of a pump. The pressure can be measured from the center line of the pump to the hydraulic grade line of the water in the discharge pipe.

DISINFECTION (DIS-in-feck-shun) | DISINFECTION

The process by which pathogenic (disease) organisms are killed. There are several ways to disinfect, but chlorination is the most frequently used method in water and wastewater treatment. Chlorination attempts to destroy all pathogens in drinking water (disinfection), but usually does not kill all pathogens in the effluent from wastewater treatment plants. In either type of water, usually all of the microorganisms are not killed.

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DISPLACED PIPE DISPLACED PIPE

A run or section of sewer pipe that has been pushed out of alignment by external forces.

DISTURBED SOIL DISTURBED SOIL

Soil which has been changed from its natural condition by excavation or other means.

DIVERSION CHAMBER DIVERSION CHAMBER

A chamber or box which contains a device for diverting or drawing off all or part of a flow or for discharging portions of the total flow to various outlets. Also called a 'REGULATOR'.

DOMESTIC DOMESTIC

Residential living facilities. A domestic area will be predominantly residential in occupancy and is sometimes referred to as a 'Bedroom Area' or 'Bedroom Community'.

DOMESTIC CONTRIBUTION DOMESTIC CONTRIBUTION

Wastes originating in a residential facility or dwelling. In this use, it differentiates the wastes by type and quantity from commercial and industrial or agricultural wastes.

DOMESTIC SERVICE DOMESTIC SERVICE

A connection to a sewer system for hookup of a residential type building.

DOWNSPOUT DOWNSPOUT

In plumbing the water conductor from the roof gutters or roof catchment to the storm drain or other means of disposal. Also called a roof leader or roof drain.

DOWNSTREAM DOWNSTREAM

The direction of the flow of water, or toward or in the lower part of a sewer or collection system.

DRAGLINE DRAGLINE

A machine that drags a bucket down the intended line of a trench to dig or excavate the trench. Also used to dig holes and move soil or aggregate.

DROP JOINT DROP JOINT

A sewer pipe joint where one part has dropped out of alignment. Also called a 'Vertical Offset'.

DROP MANHOLE DROP MANHOLE

(1) Where an inlet pipe to a manhole enters the manhole structure above the bottom or invert of the manhole and the flow from the pipe is allowed to fall or drop into the manhole.

(2) In some manholes with drop lines, a connection is made to the line outside of the manhole and the flow is conducted down to the invert or trough of the manhole through this connection.

DRY PIT DRY PIT

(See DRY WELL)

DRY WELL DRY WELL

A dry room or compartment in a lift station, near or below the water level, where the pumps are located.

DWELLING DWELLING

A structure for residential occupancy.

DYNAMIC HEAD DYNAMIC HEAD

When a pump is operating, the vertical distance (in feet) from a point to the energy grade lines. Also see TOTAL DYNAMIC HEAD and STATIC HEAD.

EARTH SHIFT EARTH SHIFT

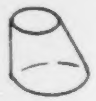
A dislocation of underground soil or structure. Generally attributed to external forces such as surface loads, slides, stresses of nearby construction, water movements or seismic forces.

EASEMENT EASEMENT

Land owned by others in which a utility agency has a legal right to use the land to install and maintain a line, such as a sewer.

ECCENTRIC MANHOLE CONE ECCENTRIC MANHOLE CONE

Cone tapers nonuniformly from barrel to manhole cover with one side usually vertical.



EFFLUENT (EF-lou-ent) EFFLUENT

Wastewater or other liquid--raw, partially or completely treated--flowing from a basin, treatment process, or treatment plant.

ELBOW ELBOW

A pipe fitting that connects two pipes at an angle. The angle is always 90 degrees unless another angle is stated. Also called an ELL.

ELECTROLYTE SOLUTION (e-LECK-tro-light) ELECTROLYTE SOLUTION

A special solution that is capable of conducting electricity.

ELECTROMOTIVE FORCE (E.M.F.) ELECTROMOTIVE FORCE

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See VOLTAGE.

ELECTRON ELECTRON

A very small, negatively-charged particle which is practically weightless. According to the electron theory, all electrical and electronic effects are caused either by the movement of electrons from place to place or because there is an excess or lack of electrons at a particular place.

EMULSION (e-MULL-shun) EMULSION

A liquid mixture of two or more liquid substances not normally dissolved in one another, but one liquid held in suspension in the other.

ENERGY GRADE LINE (E.G.L.) ENERGY GRADE LINE

A line that represents the elevation of energy head of water flowing in a pipe, conduit or channel. The line is drawn above the hydraulic grade line a distance equal to the velocity head of the water flowing at each section or point along the pipe or channel.

ESTIMATED CONTRIBUTION ESTIMATED CONTRIBUTION

A contribution to a collection system that is estimated rather than computed. The distinction between computed and estimated in such cases is difficult to specify or define.

ESTIMATED FLOW ESTIMATED FLOW

A flow in a collection system that is estimated. As different from computed, which connotes reasonable accuracy, and measured or metered, which connotes best accuracy.

EXFILTRATION (EX-fill-TRAY-shun) EXFILTRATION

Liquid wastes and liquid carried wastes which unintentionally leak out of a sewer pipe system and into the environment.

EXTRADOS EXTRADOS

The upper outside curve or surface of a sewer pipe or conduit.

EXTREMELY HAZARDOUS WASTE EXTREMELY HAZARDOUS WASTE

Any hazardous waste or mixture of hazardous wastes which, if any human exposure should occur, may likely result in death, disabling personal injury or illness during, or as approximate result of, any disposal of such waste or mixture of wastes because of its quantity, concentration, or chemical characteristics. (Subsection 23115 of Article 2, Chapter 6.5, Division 20 of the California Health and Safety Code.) Also see HAZARDOUS WASTE.

FAIR LEAD PULLEY (- LEE-d -) FAIR LEAD PULLEY

Pulley placed in manhole to guide TV camera, electric cables, and pull cable into sewer.

FAULT FAULT

(1) A geological and seismic rift in the earth generally associated with earth shifts and earthquakes.

(2) (See 'DEFECT')

FILLED DIP FILLED DIP

(See 'DIP')

FLAP GATE FLAP GATE

A gate that opens and closes by rotation around a hinge or hinges at the top side of the gate.

FLOAT (CONTROL) FLOAT (CONTROL)

A device used to measure the elevation of the surface of water. The float rests on the surface of the water and rises or falls with it. The elevation of the water surface is measured by a rod, chain, rope or tape attached to the float.

FLOAT LINE FLOAT LINE

A length of rope or heavy twine attached to a float, plastic jug or parachute to be carried by the flow in a sewer from one manhole to the next. This is called "stringing the line" and is used for pulling through winch cables, such as, for bucket machine or closed circuit television work.

FLOTATION FLOTATION

(1) The stress or forces on a pipeline or manhole structure located below a water table and which tend to cause it to lift or float.

(2) The raising of suspended matter to the surface of the liquid in a tank as scum - by aeration, the evolution of gas, chemicals, electrolysis, heat or bacterial decomposition - and the subsequent removal of the scum by skimming.

FLOTSAM (FLOAT-sam) FLOTSAM

(See 'SURFACE SOLIDS')

FLOW FLOW

The continuous movement of a liquid from one place to another.

FLOW LINE FLOW LINE

The lowest point of the channel inside a pipe or manhole. (See 'INVERT')

FLOW RECORDING FLOW RECORDING

A record of a flow measurement past any selected point. Usually consists of time, velocity and gallonages with maximum and minimum rates as well as the total amount over a given time period.

FLUME FLUME

An open conduit of wood, masonry, metal, or plastic constructed on a grade and sometimes elevated. Sometimes called an aqueduct or channel.

FLUME, PARSHALL

FLUME, PARSHALL

(See 'PARSHALL FLUME')

FLUSHER BRANCH

FLUSHER BRANCH

A line built specifically to allow the introduction of large quantities of water to the collection system so the lines can be "flushed out" with water. Also installed to provide access for equipment to clear stoppages in a sewer.

FLUSHING

FLUSHING

The removing of deposits of material which have lodged in sewers because of inadequate velocity of flows. Water is discharged into the sewers at such rates that the larger flow and higher velocities are sufficient to remove the material.

FORCE MAIN

FORCE MAIN

A pipe that conveys wastewater under pressure from the discharge side of a pump to a point of gravity flow.

FRIABILITY (FRY-ability)

FRIABILITY

The ability of a soil or substance to crumble under moderate or light pressure.

FRICTION LOSS

FRICTION LOSS

The head lost by water flowing in a stream or conduit as the result of the disturbances set up by the contact between the moving water and its containing conduit and by intermolecular friction.

FULL DIP FULL DIP

(See 'DIP')

FUSE FUSE

A protective device having a strip or wire of fusible metal which, when placed in a circuit, will melt and break the electrical circuit when subjected to an excessive temperature. This temperature will develop in the fuse when a current flows through the fuse in excess of that which the circuit will carry safely.

GAGE GAGE

A device for indicating the magnitude or position of air or water in specific units such as the elevation of a water surface, the velocity of flowing water, the pressure of water, the amount or intensity of precipitation, and the depth of snowfall. Gages also are used to determine the location or position of equipment during installation and after operation.

GAS (SEWER) GAS (SEWER)

(See 'SEWER GAS')

GEL OR GELL GEL OR GELL

(1) A term sometimes applied to chemical grout. (See 'CHEMICAL GROUT')

(2) A form of matter in a colloidal state that does not dissolve, but remains suspended in a solvent from which it does not precipitate without the intervention of heat or of an electrolyte.

GEOLOGY GEOLOGY

The science that deals with the origin, history and structure of the earth, as recorded in the rocks, together with the forces and processes now operating to modify rocks.

GEOLOGY, SUBSOIL GEOLOGY, SUBSOIL

(See 'SUBSOIL GEOLOGY')

GEOLOGY, SUBSTRUCTURE GEOLOGY, SUBSTRUCTURE

(See 'SUBSOIL GEOLOGY')

GPCD GPCD

Initials standing for "Gallons Per Capita per Day".

GPD GPD

Initials standing for "Gallons Per Day".

GPM GPM

Initials standing for "Gallons Per Minute".

GPY GPY

Initials standing for "Gallons Per Year".

GRADE GRADE

(1) The elevation of the invert of the bottom of a pipeline, canal, culvert, sewer, or similar conduit.

(2) The inclination or slope of a sewer, conduit, stream channel, or natural ground surface, usually expressed in terms of the ratio or percentage of number of units of vertical rise or fall per unit of horizontal distance.

GRANULAR GRANULAR

A solid consisting of separate granules or grains. Examples are sand and gravel.

GRAVITY GRAVITY

The attraction of the earth to any substance -- solid, liquid or gas.

GRAVITY FLOW GRAVITY FLOW

Water or wastewater flowing from a higher elevation to a lower elevation due to the force of gravity. The water does not flow due to energy provided by a pump. Wherever possible, wastewater collection systems are designed to use the force of gravity to convey waste liquids and solids.

GRAVITY, SPECIFIC GRAVITY, SPECIFIC

(See 'SPECIFIC GRAVITY')

GREASE **GREASE**

In a collection system, grease is considered to be the residues of fats, detergents, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and certain other nonfatty materials which tend to separate from water and coagulate as floatables or scums.

GREASE BUILD UP **GREASE BUILD UP**

Any point in a collection system where coagulated and solidified greases accumulate and build up. Many varieties of grease have high adhesive characteristics and collect other solids, forming restrictions and stoppages in collection systems.

GREASE TRAP **GREASE TRAP**

A receptacle designed to collect and retain grease and fatty substances usually found in kitchens or from similar wastes. It is installed in the drainage system between the kitchen or other point of production of the waste and the building wastewater collection line.

GRIT **GRIT**

The heavy mineral material present in wastewater such as sand, coffee grounds, eggshells, gravel and cinders. Grit tends to settle out at flow velocities below 2 ft/sec and accumulate in the invert or bottoms of the pipelines.

GRIT CATCHER **GRIT CATCHER**

A chamber usually placed at the upper end of a depressed collection line or at other points on combined or storm collection lines where wear from grit is possible; the chamber is sized and shaped to reduce the velocity of flow through it and thus permit the settling out of grit. Also called sand catcher. See GRIT CHAMBER.

GRIT CHAMBER GRIT CHAMBER

A detention chamber or an enlargement of a collection line designed to reduce the velocity of flow of the liquid to permit the separation of mineral from organic solids by differential sedimentation.

GRIT CHANNEL GRIT CHANNEL

(1) An enlargement in a collection line providing an opportunity for the deposition of grit.

(2) The waterway of a grit chamber.

GRIT COLLECTOR GRIT COLLECTOR

A device placed in a grit chamber to convey deposited grit to a point of collection.

GRIT COMPARTMENT GRIT COMPARTMENT

The portion of the grit chamber in which grit is collected and stored before removal.

GRIT SEPARATOR GRIT SEPARATOR

A device located at the inlet to a treatment plant for the accumulation of grit and the removal of grit.

GRIT TRAP GRIT TRAP

(1) A permanent structure built into a manhole or other convenient location in a collection system for the accumulation and easy removal of grit.

(2) (See 'SAND TRAP')

GROUND WATER GROUND WATER

Subsurface water occupying the saturation zone from which wells and springs are fed. In a strict sense the term applies only to water below the water table. Also called phreatic water and plerotic water.

GROUND WATER DEPTH GROUND WATER DEPTH

The distance of the ground water table below the surface at any selected location.

GROUND WATER ELEVATION GROUND WATER ELEVATION

The elevation of the ground water table above mean sea level at any selected location.

GROUND WATER TABLE GROUND WATER TABLE

The average depth or elevation of the ground water over a selected area.

GROUND WATER TABLE, ARTIFICIAL GROUND WATER TABLE, ARTIFICIAL

(See 'ARTIFICIAL GROUND WATER TABLE')

GROUND WATER TABLE, SEASONAL GROUND WATER TABLE, SEASONAL

(See 'SEASONAL GROUND WATER TABLE')

GROUND WATER TABLE, TEMPORARY
GROUND WATER TABLE, TEMPORARY

(See 'TEMPORARY GROUND WATER TABLE')

GROUT
GROUT

A substance in a paste or liquid form which solidifies after placement or treatment. Used to fill spaces, holes or voids in other materials.

GROUT, CHEMICAL
GROUT, CHEMICAL

(See 'CHEMICAL GROUT')

GROUTING, PRESSURE
GROUTING, PRESSURE

(See 'CHEMICAL GROUTING')

HAIRLINE CRACK
HAIRLINE CRACK

A stress crack in a pipe that looks like a piece of hair.

HAND ROD
HAND ROD

A sewer rod that can be inserted manually (by hand) into a sewer to clear a stoppage or to prevent a stoppage from developing.

HANDHOLE TRAP
HANDHOLE TRAP

A device made of pipe fittings used to prevent sewer gases escaping from the branch or lateral sewer from entering a building sewer.

HAZARDOUS WASTE HAZARDOUS WASTE

Any waste material or mixture of wastes which is toxic, corrosive, flammable, an irritant, a strong sensitizer which generates pressure through decomposition, heat or other means, if such a waste or mixture of wastes may cause substantial personal injury, serious illness or harm to wildlife, during, or as approximate result of any disposal of such wastes or mixture of wastes. The term "toxic", "corrosive", "flammable", "irritant", and "strong sensitizer" shall be given the same meaning as the California Hazardous Substance Act (Chapter 13 (commencing with Section 28740) of Division 21) (Subsection 23117 of Article 2, Chapter 6.5, Division 20 of the California Health and Safety Code). Also see EXTREMELY HAZARDOUS WASTE.

HEAD HEAD

A term used to describe the height or energy of water above a point. A head of water may be measured in either height (feet) or pressure (pound per square inch (psi)). Also see DISCHARGE HEAD, DYNAMIC HEAD, STATIC HEAD, SUCTION HEAD, SUCTION LIFT, and VELOCITY HEAD.

HERTZ (HURTS) HERTZ

Number of complete electromagnetic cycles or waves in one second of an electrical or electronic circuit. Also called the frequency of the current. Abbreviated Hz.

HIGH VELOCITY CLEANER HIGH VELOCITY CLEANER

A machine designed to remove grease and debris from the smaller diameter sewer pipes with jets of high velocity water. Also called a 'Jet Cleaner', 'Jet Rodder', 'Hydraulic Cleaner', or 'High Pressure Cleaner'.

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HOUSE CONNECTION HOUSE CONNECTION

(See 'BUILDING SEWER')

HOUSE SERVICE HOUSE SERVICE

(See 'BUILDING SERVICE')

HOUSE SEWER HOUSE SEWER

(See 'BUILDING SEWER')

HUB HUB

In pipe fitting, the recessed, overenlarged female end of a pipe into which the male end fits. Also called a BELL.

HYDRAULIC BLOCK HYDRAULIC BLOCK

The movement of water in such a way that the flow of water from one direction blocks or hinders the flow of water from another direction.

HYDRAULIC CLEANER HYDRAULIC CLEANER

(See 'HIGH VELOCITY CLEANER')

HYDRAULIC CLEANING	HYDRAULIC CLEANING

Cleaning pipe with water under pressure that produces high water velocities.

(1) Using a high velocity cleaner.

(2) Using a ball, kite or similar sewer cleaning device.

(3) Using a scooter.

(4) Flushing.

HYDRAULIC GRADE LINE (H.G.L.)	HYDRAULIC GRADE LINE

The surface or profile of water flowing in an open channel or a pipe flowing partially full. If a pipe is under pressure, the hydraulic grade line is at the level water would rise to in a small tube connected to the pipe. To reduce the release of odors from sewers, the water surface should be kept as smooth as possible.

HYDROGEN SULFIDE GAS (H_2S)	HYDROGEN SULFIDE GAS (H_2S)

A flammable, explosive, poisonous gas with a rotten egg odor found in wastewater collection systems.

HYDROLOGY	HYDROLOGY

The applied science concerned with the waters of the earth in all their states - their occurrence, distribution, and circulation through the unending hydrologic cycle of precipitation, consequent runoff, stream flow, infiltration, and storage, eventual evaporation, and reprecipitation. Hydrology is concerned with the physical, chemical, and physiological reactions of water with the rest of the earth and its relation to the life of the earth.

IMPELLER IMPELLER

A rotating set of vanes in a pump designed to pump or lift water.

IMPORTED BACKFILL IMPORTED BACKFILL

Material used for backfilling a trench or excavation which was not the original material removed during excavation. This is a common practice where tests on the original material show it to have poor compactability or load capacity. Also called 'BORROW BACKFILL'.

INDUSTRIAL TELEVISION EQUIPMENT INDUSTRIAL TELEVISION EQUIPMENT

(See 'INSPECTION TELEVISION CAMERA')

INDUSTRIAL WASTEWATER INDUSTRIAL WASTEWATER

Liquid wastes originating from industrial processing. Because industries have peculiar liquid waste characteristics, requiring special consideration, these sources are usually handled and treated separately.

INFILTRATED DEBRIS INFILTRATED DEBRIS

Sand, silt, gravel and rocks carried or washed into a collection system by infiltration water flows.

INFILTRATION INFILTRATION

The water entering a sewer system, including service connections, from the ground, through such means as, but not limited to, defective pipes, pipe joints, connections or manhole walls.

INFILTRATION/INFLOW INFILTRATION/INFLOW

The total quantity of water from both infiltration and inflow without distinguishing the source.

INFILTRATION HEAD INFILTRATION HEAD

The distance from a point of infiltration leaking into a collection system to the water table elevation. This is the pressure of the water being forced through the leak in the collection system.

INFILTRATION PRESSURE INFILTRATION PRESSURE

(See 'INFILTRATION HEAD')

INFILTRATION, TEMPORARY INFILTRATION, TEMPORARY

(See 'TEMPORARY INFILTRATION')

INFLATABLE PIPE STOPPER INFLATABLE PIPE STOPPER

An inflatable ball or bag used to form a plug to stop flows in a sewer pipe.

INFLOW INFLOW

The water discharged into a sewer system and service connections from such sources as, but not limited to, roof leaders, cellar, yard and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, around manhole covers or through holes in the covers, cross connections from storm and combined sewer systems, catch basins, storm waters, surface run-off, street wash waters or drainage. See INTERNAL FLOW.

INFLUENT (IN-flu-ent) INFLUENT

Wastewater or other liquid -- raw or partially treated -- flowing into a reservoir, basin, treatment process, or treatment plant.

INORGANIC WASTE INORGANIC WASTE

Waste material such as sand, salt, iron, calcium, and other mineral materials which are not converted in large quantities by organism action. Inorganic wastes are chemical substances of mineral origin. Organic wastes are chemical substances of animal or vegetable origin.

INSPECTION TELEVISION EQUIPMENT INSPECTION TELEVISION EQUIPMENT

Television equipment superior to standard commercial quality, providing 600 to 650 lines of resolution, and designed for industrial inspection applications. Also known as INDUSTRIAL TELEVISION EQUIPMENT.

INTERCEPTING SEWER INTERCEPTING SEWER

A sewer that receives flow from a number of other large sewers or outlets and conducts the waters to a point for treatment or disposal. Often called an INTERCEPTOR.

INTERCONNECTOR INTERCONNECTOR

A sewer installed to connect two separate sewers. If one sewer becomes blocked, wastewater can back up and flow through the interconnector to the other sewer.

INTERNAL INFLOW INTERNAL INFLOW

Non-sanitary or industrial wastewaters generated inside of a domestic, commercial or industrial facility and being discharged into the sewer system. Examples are cooling tower waters, basement sump pump discharge waters, continuous-flow drinking fountains, and defective or leaking plumbing fixtures.

INTRADOS INTRADOS

The upper inside curve or surface of a sewer pipe or conduit.

INVERT INVERT

The lowest point of the channel inside a pipe or manhole. (See 'FLOW LINE')

INVERTED SIPHON INVERTED SIPHON

A pressure pipeline used to carry wastewater flowing in a gravity collection system under a depression such as a valley or roadway or under a structure such as a building. Also called a 'DEPRESSED SEWER'.

JET CLEANER JET CLEANER

(See 'HIGH VELOCITY CLEANER')

JET RODDER JET RODDER

(See 'HIGH VELOCITY CLEANER')

JETSAM (JET-sam) JETSAM

Debris entering a collection system which is heavier than water. (See 'GRIT')

JOINT JOINT

A connection between two lengths of pipe, made either with or without the use of another part.

KEY MANHOLE KEY MANHOLE

In collection system evaluation, a key manhole is one from which reliable or specific data can be obtained.

KITE KITE

A device for hydraulically cleaning sewer lines. Resembling an airport wind sock and constructed of canvas type material, the kite increases the velocity of a flow at its outlet to wash debris ahead of it.

LAMP HOLE LAMP HOLE

A small vertical pipe or shaft extending from the surface of the ground to a sewer. A light (or lamp) may be lowered down the pipe for the purpose of inspecting the sewer. Rarely constructed today.

LAMPING LAMPING

Using reflected sunlight or a powerful light beam to inspect a sewer between two adjacent manholes. The light is directed down the pipe from one manhole. If it can be seen from the next manhole, it indicates that the line is open and straight.

LATERAL LATERAL

(See 'BUILDING LATERAL')

LATERAL BREAK LATERAL BREAK

A break in a lateral pipe somewhere between the sewer main and the building connection.

LATERAL CLEANOUT LATERAL CLEANOUT

A cleanout for a building lateral, usually located on the property line.

LATERAL CONNECTION LATERAL CONNECTION

(See 'BUILDING SERVICE')

LATERAL SEWER LATERAL SEWER

A sewer that discharges into a branch or other sewer and has no other common sewer tributary to it. Sometimes called a 'STREET SEWER' because it collects wastewater from individual homes.

LEAD (LEE-d) LEAD

A wire or conductor that can carry electrcity.

LIFT STATION LIFT STATION

A wastewater pumping station that lifts the wastewater to a higher elevation when the continuance of the sewer at reasonable slopes would involve excessive depths of trench, or that raises wastewater from areas too low to drain into available sewers. These stations may be equipped with air-operated ejectors or centrifugal pumps. Sometimes called a 'PUMP STATION'. The term 'PUMP STATION' is usually reserved for a similar type of facility that is discharging into a long 'FORCE MAIN', while a lift station has a discharge line or force main only up the downstream gravity sewer. Throughout this manual when we refer to lift stations, we intend to include pump stations.

LINER LINER

(See 'PIPE LINER')

LIQUID VEHICLE LIQUID VEHICLE

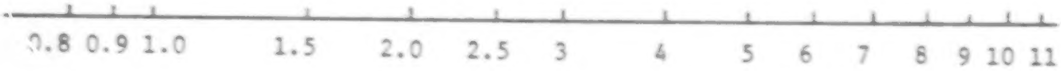
Water in a collection system that is used to carry non-liquid wastes. The standard closet bowl provides around seven gallons of water per flush as a vehicle to carry wastes through the pipe system.

LIQUOR LIQUOR

Water, wastewater, or any combination; commonly used to designate liquid phase when other phases are present.

LOGARITHMIC SCALE (LOG-a-rith-mick) LOGARITHMIC SCALE

A logarithmic scale has the numbers getting smaller as the distances between the numbers increases.



LONGITUDINAL CRACK LONGITUDINAL CRACK

A crack in a pipe or pipe section that runs lengthwise along the pipe.

LUBRIFLUSHING LUBRIFLUSHING

Where bearings are grease lubricated, remove relief plug and apply proper lubricant to the bearing at the lubrication fitting. Run pump and expel excess lubricant.

M-ZONED M-ZONED

An area set aside for manufacturing and industry.

MAIN LINE MAIN LINE

Branch or lateral sewers that collect wastewater from building sewers and service lines.

MAIN SEWER MAIN SEWER

A sewer line that receives wastewater from many tributary branches and sewer lines and serves as an outlet for a large territory.

MANDREL (MAN-drill) MANDREL

(1) A special tool used to push bearings in or to pull sleeves out.

(2) A gage used to measure for excessive deflection in a flexible conduit.

MANHOLE MANHOLE

An opening in a sewer provided for the purpose of permitting workers or equipment to enter or leave a sewer. Sometimes called an ACCESS HOLE.

MANHOLE BEDDING MANHOLE BEDDING

The prepared and compacted base on which a manhole is constructed.

MANHOLE DEPTH MANHOLE DEPTH

The measurement from the top of the manhole opening to the invert or lowest point of the trough at the bottom of the manhole.

MANHOLE, DROP MANHOLE, DROP

(See 'DROP MANHOLE')

MANHOLE ELEVATION MANHOLE ELEVATION

The elevation of the invert or lowest point in the bottom of a manhole above mean sea level.

MANHOLE FLOW MANHOLE FLOW

(1) The depth or amount of wastewater flow in a manhole as observed at any selected time.

(2) The total or the average flow through a manhole in gallons in any selected time interval.

MANHOLE FRAME MANHOLE FRAME

A metal ring or frame with a ledge to accomodate the lid and located at the surface of the ground or street. Also called a 'MANHOLE RING'.

MANHOLE INFILTRATION MANHOLE INFILTRATION

Ground waters seeping or leaking into a manhole structure.

MANHOLE INFLOW MANHOLE INFLOW

Surface waters flowing into a manhole, usually through the vent holes in the manhole lid.

MANHOLE INVERT MANHOLE INVERT

The lowest point in a trough or flow channel in the bottom of a manhole.

MANHOLE, KEY MANHOLE, KEY

(See 'KEY MANHOLE')

MANHOLE LID MANHOLE LID

The heavy cast iron or forged steel cover of a manhole. The lid may or may not have vent holes.

MANHOLE LID DUST PAN MANHOLE LID DUST PAN

A sheet metal or cast iron pan located under a manhole lid. This pan serves to catch and hold pebbles and other debris falling through vent holes, preventing them from getting into the pipe system.

MANHOLE RING MANHOLE RING

A metal frame or ring with a ledge to accomodate the lid and located at the surface of the ground or street. Also called a 'MANHOLE FRAME'.

MANHOLE SEALING MANHOLE SEALING

Sealing infiltration leaks in a manhole by injecting chemical grout.

MANHOLE, SURCHARGED MANHOLE, SURCHARGED

(See 'SURCHARGED MANHOLE')

MANHOLE TOOLS MANHOLE TOOLS

(1) Special tools having conveniently short handles for working inside of manholes.

(2) Special long handled or extendable tools for removal of debris and other objects from manholes without requiring a person to enter the manhole.

MANHOLE TROUGH MANHOLE TROUGH

The channel in the bottom of a manhole for the flow of the wastewater from manhole inlet to cutlet.

MANHOLE VENTS MANHOLE VENTS

One or a series of one-inch diameter holes through a manhole lid for purposes of venting off dangerous gases found in sewers.

MANNING'S FORMULA MANNING'S FORMULA

A mathematical formula for calculating wastewater flows in sewers.

MANNING'S TABLES MANNING'S TABLES

A set of tables for finding wastewater flows in sewers.

MANOMETER (man-NOM-meet-her) MANOMETER

Usually a glass tube filled with a liquid and used to measure the difference in pressure across a flow measuring device such as an orifice or a venturi meter.

MEASURED FLOW MEASURED FLOW

A flow which has been physically measured. (See 'GAGE')

MECHANICAL CLEANING MECHANICAL CLEANING

Clearing pipe by using equipment that scrapes, cuts, pulls or pushes the material out of the pipe. Mechanical cleaning devices or machines include bucket machines, power rodders and hand rods.

MECHANICAL PLUG MECHANICAL PLUG

A pipe plug used in sewer systems that is mechanically expanded to create a seal.

MEGGER (from "megohm") MEGGER

An instrument used for checking the insulation resistance on motors, feeders, buss bar systems, grounds, and branch circuit wiring.

METERED METERED

A quantity of water or flow which is measured through a meter.

MG MG

Initials for "Million Gallons."

MGD MGD

Initials for "Million Gallons per Day."

mg/l mg/l

Initials for "Milligrams per Liter". A unit of the concentration of a constituent in water or wastewater. It is preferred to the unit, parts per million (PPM), to which it is approximately equivalent, in reporting the results of water and wastewater analysis.

MGY MGY

Initials for "Million Gallons per Year".

MICROORGANISMS (micro-ORGAN-is-zums) MICROORGANISMS

Very small organisms that can be seen only through a microscope. Some microorganisms use the wastes in wastewater for food and thus remove or alter much of the undesirable matter.

MILLION GALLONS

MILLION GALLONS

A unit of measurement used in wastewater treatment plant design and collection system capacities or performances.

One million gallons of water is approximately equivalent to:

13,690	Cubic Feet
3.07	Acre-Feet
8,340,000	Pounds of Weight
3,723	Tons of Weight
3,785	Cubic Meters

MINERAL

MINERAL

Any substance that is neither animal nor vegetable. Minerals include sand, salt, iron, calcium, and nutrients.

MINERAL CONTENT

MINERAL CONTENT

The quantity of dissolved minerals in a sample of water.

MONITOR

MONITOR

(1) (See 'CONDUCTOR')

(2) (See 'TELEVISION MONITOR')

"N" FACTOR

"N" FACTOR

A coefficient value representing roughness or friction loss in Manning's formula for computing flows in gravity sewers. (See 'FRICTION LOSS')

NET WASTEWATER CONTRIBUTION NET WASTEWATER CONTRIBUTION

In a wastewater collection system, the net wastewater contribution consists of the liquid wastes and liquid carried wastes transported by the pipelines or received by the pipelines. This value would be the only wastewater found in a collection system if all sources of infiltration, inflow and exfiltration were eliminated.

NET WASTEWATER FLOW NET WASTEWATER FLOW

The actual wastewater flow from a collection system that reaches a wastewater treatment plant. The net wastewater flow includes the net wastewater contribution, infiltration and inflow and less losses through exfiltration.

NODULAR (NOD-you-lar) NODULAR

Shaped like a rounded lump, knot or knob. An irregular enlargement.

NOMINAL DIAMETER NOMINAL DIAMETER

Approximate diameter of a pipe; used to describe the size or diameter of a pipe.

NOMOGRAPH (NOME-o-graph) NOMOGRAPH

A graphic representation or means of solving an equation or mathematical relationship. Results are obtained with the aid of a straightedge placed over important known values.

OBSTRUCTION OBSTRUCTION

Any solid object in or protruding into a wastewater flow in a collection line that prevents a smooth or even passage of the wastewater.

OFF LINE OFF LINE

A run of sewer pipe between two manholes is said to be 'off line' if it is not located directly under a straight line passing through the exact centers of the two manholes. Sewer alignment does not always pass through the center of a manhole, especially at junctions. Also called 'off line' or 'misaligned'.

OFFSET OFFSET

(1) A combination of elbows or bends which brings one section of a line of pipe out of line with, but into a line parallel with, another section.

(2) A pipe fitting in the approximate form of a reverse curve, made to accomplish the same purpose.

(3) A pipe joint that has lost its bedding support and one of the pipe sections has dropped or slipped, thus creating a condition where the pipes no longer line up properly.

OFFSET INVERT OFFSET INVERT

A trough or channel in the bottom of a manhole which is not centered in the bottom.

OFFSET JOINT OFFSET JOINT

A pipe joint that is not exactly in line and centered. (See 'DROP JOINT' and 'VERTICAL OFFSET')

OFFSET MANHOLE OFFSET MANHOLE

A manhole located to one side of a pipe run with either "Y" connections to it or the inlet and outlet pipes bent to enter and leave the manhole.

OFFSET PIPE OFFSET PIPE

(See 'OFF LINE')

OFFSET TROUGH OFFSET TROUGH

(1) When the pipe feeding into a manhole does not exactly match up with the pipe leading out of the manhole, the invert channel must be angled or curved. This is referred to as an 'offset trough'.

(2) (See 'OFFSET INVERT')

OHM OHM

The unit of electrical resistance. The resistance of a conductor in which one volt produces a current of one ampere.

OLFACTORY FATIGUE (ol-FACTORY) OLFACTORY FATIGUE

When our nose becomes tired of or dull from smelling a particular odor and can no longer detect the presence of the odor.

ORGANIC WASTE ORGANIC WASTE

Waste material which comes from animal or vegetable sources. Organic wastes generally can be consumed by bacteria and other small organisms. Inorganic wastes are chemical substances of mineral origin.

ORIFICE (OR-i-fiss) ORIFICE

An opening in a plate, wall, or partition. An orifice flange set in a pipe consists of a slot or hole smaller than the pipe diameter. The difference in pressure in the pipe above and below the orifice may be related to flow in the pipe.

OUTFALL OUTFALL

(1) The point, location or structure where wastewater or drainage discharges from a sewer, drain, or other conduit.

(2) The conduit leading to the ultimate disposal area. See 'OUTFALL SEWER'.

OUTFALL SEWER OUTFALL SEWER

A sewer that receives wastewater from a collection system or from a wastewater treatment plant and carries it to a point of ultimate discharge in the environment. See 'OUTFALL'.

OUTLET OUTLET

Downstream opening or discharge end of a pipe, culvert, or canal.

OVERFLOW MANHOLE OVERFLOW MANHOLE

A manhole which fills and allows raw wastewater to flow out onto the street or ground.

OVERFLOW RELIEF LINE OVERFLOW RELIEF LINE

Where a system has overload conditions during peak flows, an outlet above the invert, leading to a less loaded manhole or part of the system may be installed. This is usually called an 'overflow relief line'. Also see 'CROSS CONNECTION (2)'.

OXIDATION (ox-i-DAY-shun) OXIDATION

The addition of oxygen to a compound. More generally, any reaction which involves the loss of electrons from an atom.

OXIDATION-REDUCTION POTENTIAL OXIDATION-REDUCTION POTENTIAL

The potential required to transfer electrons from the oxidant to the reductant and used as a qualitative measure of the state of oxidation in wastewater treatment systems.

PACKER PACKER

(See 'CHEMICAL GROUTING')

PACKING RING PACKING RING

A ring made of asbestos or metal which may be lubricated with Teflon or graphite that forms a seal between the pump shaft and its casing.

PARACHUTE PARACHUTE

A device used to catch wastewater flow to pull a float line between manholes. (See 'FLOAT LINE')

PARSHALL FLUME PARSHALL FLUME

A specially constructed flume used to measure gallonages of flow in open channels.

PATHOGENIC ORGANISMS PATHOGENIC ORGANISMS
(PATH-o-JEN-nick OR-gan-iz-ums)

Bacteria or viruses which can cause disease (for examples typhoid, cholera, dysentery). There are many types of bacteria which do not cause disease and which are not called pathogenic. Many beneficial bacteria are found in wastewater treatment processes actively cleaning up organic wastes.

PERCOLATION PERCOLATION

Water seeping or passing through soil.

PHOTOGRAPHIC INSPECTIONS PHOTOGRAPHIC INSPECTIONS

A method of obtaining photographs of a pipeline by pulling a time-lapse motion picture camera through the line. By moving the camera a specific distance at timed intervals, a sequence of photographs covering the full length of the line are obtained.

PHOTOGRAPHIC RECORDS PHOTOGRAPHIC RECORDS

(1) The film strip from a photographic inspection.

(2) Still camera photographs of a sewer television inspection monitor.

PIPE BEDDING PIPE BEDDING

(See 'BEDDING' and 'BEDDING GRADE')

PIPE BUCKET PIPE BUCKET

(See 'BUCKET' and 'BUCKET MACHINE')

PIPE CAPACITY PIPE CAPACITY

In a gravity flow sewer system, pipe capacity is the total gallonage a pipe is able to pass in a specific time period.

PIPE CLEANING PIPE CLEANING

Removing grease, grit, roots and other debris from a pipe run by means of one of the hydraulic cleaning methods (See 'BALLING', 'HYDRAULIC CLEANING' and 'KITE').

NOTE: While rodding may be used to open a pipe stoppage or to remove roots and greases, it is not known to remove grit and similar debris.

PIPE DEFLECTION PIPE DEFLECTION

(See 'DEFLECTED')

PIPE DIAMETER PIPE DIAMETER

The nominal or commercially designated inside diameter of a pipe, unless otherwise stated.

PIPE DIP PIPE DIP

(See 'DIP')

PIPE DISPLACEMENT PIPE DISPLACEMENT

(1) The cubic inches of soil or water displaced by one foot or one section of pipe.

(2) (See 'DISPLACED PIPE')

PIPE GRADE PIPE GRADE

The grade of a sewer or a single section of a sewer as installed. Usually expressed in a percentage figure to indicate the drop in feet or tenths of a foot per hundred feet, such as 0.5%.

PIPE JACK PIPE JACK

A jack used to fasten roller guides to secure an object within a manhole.

PIPE JOINT PIPE JOINT

A place where two sections of pipe are coupled.

PIPE JOINT SEAL PIPE JOINT SEAL

(1) The tightness or lack of leakage at a pipe joint.

(2) The method of sealing a pipe coupling.

PIPE LINER PIPE LINER

A plastic liner pulled or pushed into a pipe to eliminate excessive infiltration or exfiltration. Other types of liners include cast iron pipe or a cement grouting.

PIPE PLUG

PIPE PLUG

(1) A temporary plug placed in a sewer pipe to stop a flow while repair work is being accomplished or other functions requiring the flow to be discontinued.

(2) In construction of a new sewer system, service saddles are sometimes installed before a building or a building lateral is in existence. Under such circumstances, a plug will be placed in the off-lead of the saddle of a "Y". In some instances, this plug may be called a 'button' or a 'stopper.'

PIPE PLUG, INFLATABLE

PIPE PLUG, INFLATABLE

(See 'INFLATABLE PIPE STOPPER')

PIPE PLUG, MECHANICAL

PIPE PLUG, MECHANICAL

(See 'MECHANICAL PLUG')

PIPE RODDING

PIPE RODDING

A method of opening a plugged or blocked pipe by pushing a steel rod or snake, or pulling same, through the pipe with a tool attached to the end of the rod or snake. Rotating the rod or snake with a tool attached increases effectiveness.

PIPE RUN

PIPE RUN

(1) The length of sewer pipe reaching from one manhole to the next. (See 'BARREL').

(2) Any length of pipe, generaly considered to be in a straight line.

PIPE SEAL PIPE SEAL

(See 'PIPE JOINT SEAL')

PIPE SEALING PIPE SEALING

(See 'CHEMICAL GROUTING')

PIPE SECTION PIPE SECTION

A single length of pipe between two joints or couplers.

PIPE SINK PIPE SINK

(See 'DIP')

PLANT PLANT

(See 'TREATMENT PLANT')

PLANT HYDRAULIC CAPACITY PLANT HYDRAULIC CAPACITY

The flow or load, in millions of gallons per day (or fraction thereof) that a treatment plant is designed to handle.

PLANT, TREATMENT PLANT, TREATMENT

(See 'WASTEWATER TREATMENT PLANT')

PLUG PLUG

(See 'INFLATABLE PIPE STOPPER' and 'MECHANICAL PLUG')

PNEUMATIC EJECTOR (NEW-MAT-tik E-JECT-tor) **PNEUMATIC EJECTOR**

A device for raising wastewater, sludge or other liquid by alternately admitting it through an inward-swinging check valve into the bottom of an airtight pot and then discharging it through an outward-swinging check valve by admitting compressed air to the pot above the wastewater.

POLLUTION **POLLUTION**

(1) Any interference with a beneficial use of water or failure to meet water quality requirements.

(2) A condition created by the presence of harmful or objectionable material in water. Also see 'CONTAMINATION'.

POLE SHADER **POLE SHADER**

Separations on the iron core inside the coil of a magnetic starter.

POLYMER **POLYMER**

A high-molecular-weight substance that is formed by either a natural or synthetic process. Natural polymers may be of biological origin or derived from starch products, cellulose derivatives, and alginates. Synthetic polymers consist of simple substances that have been made into complex, high molecular weight substances. Often called a POLYELECTROLYTE.

POTABLE WATER (PO-ta-ble) **POTABLE WATER**

Water that does not contain objectionable pollution, contamination, minerals, or infective agents and is considered satisfactory for human consumption.

POWER RODDER **POWER RODDER**

A sewer clearing machine fitted with auger rods which are inserted in a sewer line to dislodge and cut roots and debris.

PPM PPM

Initials for "Parts Per Million". The number of weight or volume units of a minor constituent present with each one million units of the major constituent of a solution or mixture. Used to express the results of most water and wastewater analyses, but more recently milligrams per liter (mg/l) is the preferred term.

PRECIPITATION PRECIPITATION

(1) The total measurable supply of water received directly from clouds as rain, snow, hail, or sleet; usually expressed as depth in a day, month, or year, and designated as daily, monthly, or annual precipitation.

(2) The process by which atmospheric moisture is discharged onto a land or water surface.

(3) The phenomenon that occurs when a substance held in a solution in a liquid passes out of solution into solid form.

PRESSURE GROUTING PRESSURE GROUTING

(See 'CHEMICAL GROUTING')

PRESSURE HEAD PRESSURE HEAD

(1) The height of a water surface above a specific point of reference. Usually measured in feet and tenths of a foot.

(2) The head represented by the expression of pressure over weight (p/w), where p is pressure (lbs/sq ft) and w is weight (lbs/cu ft).

PRESSURE MAIN

PRESSURE MAIN

(See 'FORCE MAIN')

PREVENTIVE MAINTENANCE

PREVENTIVE MAINTENANCE

To perform the most effective maintenance procedure, in the area where it is most needed, at the proper time.

PROBE

PROBE

A T-shaped tool or rod that is pushed or driven down through the soil to locate underground pipes and utility conduits. Also see 'SOUNDING ROD'.

PROTRUDING SERVICE

PROTRUDING SERVICE

The connection of a building lateral to a main sewer line whereby a hole is cut in the main and the end of the building lateral is allowed to extend into the main.

PROTRUDING TAP

PROTRUDING TAP

(See 'PROTRUDING SERVICE')

PUMP

PUMP

A mechanical device for causing flow, for raising or lifting water or other fluid, or for applying pressure to fluids.

PUMP PIT

PUMP PIT

A dry well, chamber or room below ground level in which a pump is located.

PUMP STATION PUMP STATION

A pumping station that lifts the wastewater to a higher elevation when the continuance of the sewer at reasonable slopes would involve excessive depths of trench, or that raises wastewater from areas too low to drain into available collection lines. These stations may be equipped with air operated ejectors or centrifugal pumps. (See 'LIFT STATION')

PUTREFACTION **(PU-tre-fack-shun)** PUTREFACTION

Biological decomposition of organic matter with the production of ill-smelling products associated with anaerobic conditions.

PUTRESCIBLE (pu-TRES-sib-bull) PUTRESCIBLE

Putrescible material will decompose under anaerobic condition and produce nuisance odors.

QUADRANT QUADRANT

In television and direct visual pipe inspections, four quadrants are used to identify the location of observed objects.

QUICK AIR TEST QUICK AIR TEST

The same as a quick test with a packer for chemical grouting except that air pressure is used in place of liquid for a faster test and greater accuracy.

QUICK TEST QUICK TEST

Using a packer designed for chemical grouting to pressure test any selected small area of a pipeline.

QUICKSAND QUICKSAND

Sand that has lost its grain-to-grain contact by the buoyancy effect of water flowing upward through the voids. Such material, having some of the characteristics of a fluid, possesses no load-bearing value.

"R" FACTOR "R" FACTOR

Refers to "Roughness Factor'. (See 'FRICTION LOSS' and "N" FACTOR)

R-ZONED R-ZONED

Areas established for residential occupancy.

RAIN RAIN

Particles of liquid water that have become too large to be held by the atmosphere. Their diameter generally is greater than 0.02 inch and they usually fall to the earth at velocities greater than 10 fps in still air. See 'PRECIPITATION'.

RECORDINGS, FLOW RECORDINGS, FLOW

(See 'FLOW RECORDINGS')

RECORDINGS, PHOTOGRAPHIC RECORDINGS, PHOTOGRAPHIC

(See 'PHOTOGRAPHIC RECORDS')

RECORDINGS, VIDEO RECORDINGS, VIDEO

(See 'VIDEO RECORDING')

RECORDINGS, WRITTEN RECORDINGS, WRITTEN

(See 'TELEVISION INSPECTION LOG')

REDUCTANT REDUCTANT

A constituent of wastewater or surface waters that uses either free (O_2) or combined oxygen in the process of stabilization.

REGULATOR REGULATOR

A device used in combined sewers to control or regulate the diversion of flow.

RELIEF BY-PASS RELIEF BY-PASS

(See 'BY-PASS' and 'OVERFLOW RELIEF LINE')

RELIEF LINE RELIEF LINE

(See 'OVERFLOW RELIEF LINE')

RESISTANCE RESISTANCE

That property of a conductor or wire that opposes the passage of a current, thus causing electrical energy to be transformed into heat.

RETENTION **RETENTION**

(1) That part of the precipitation falling on a drainage area which does not escape as surface streamflow, during a given period. It is the difference between total precipitation and total runoff during the period, and represents evaporation, transpiration, sub-surface leakage, infiltration, and, when short periods are considered, temporary surface or underground storage on the area.

(2) The delay or holding of the flow of water and water carried wastes in a pipe system. This can be due to a restriction in the pipe, a stoppage or a dip. Also the time water is held or stored in a basin or wet well. This is also called 'DETENTION'.

ROD GUIDE **ROD GUIDE**

A bent pipe inserted in a manhole to guide hand and power rods into collection lines so the rods can dislodge obstructions.

ROD (SEWER) **ROD (SEWER)**

A light metal rod, three to five feet long with a coupling at each end. Rods are joined and pushed into a sewer to dislodge obstructions.

RODDING **RODDING**

(See 'PIPE RODDING')

RODDING MACHINE **RODDING MACHINE**

A machine designed to feed a rod into a pipe while rotating it. (See 'PIPE RODDING')

RODDING TOOLS RODDING TOOLS

Special tools attached to the end of a rod or snake to accomplish various results in pipe rodding.

ROTOMETER (ROW-tow-meter) ROTOMETER

A device used to monitor or meter the flow or application of chemicals.

ROOF LEADER ROOF LEADER

A downspout or pipe installed to drain a roof gutter to a storm drain or other means of disposal.

ROOT, SEWER ROOT, SEWER

Any part of a root system of a plant or tree that enters a collection system.

ROOT MOP ROOT MOP

When roots, from plant life enter a sewer system, the roots frequently branch to form a growth that resembles a string mop.

ROUGHNESS COEFFICIENT ROUGHNESS COEFFICIENT

A value used in Manning's formula to determine energy losses of flowing water due to pipe wall roughness. (See 'FRICTION LOSS', "N" FACTOR and "R" FACTOR)

ROUGHNESS FACTOR ROUGHNESS FACTOR

(See 'ROUGHNESS COEFFICIENT')

RUNOFF RUNOFF

That part of rain or other precipitation that runs off the surface of a drainage area and does not enter the soil or the sewer system as inflow.

SADDLE CONNECTION SADDLE CONNECTION

A building service connection made to a sewer main with a device called a saddle. This device makes a tight seal against the main pipe by use of a clamp, adhesive, or gasket and prevents the service pipe from protruding into the main.

SAND TRAP SAND TRAP

A device which can be placed in the outlet of a manhole to cause a settling pond to develop in the manhole invert, thus trapping sand, rocks and similar debris heavier than water. Also may be installed in outlets from car wash areas. (See 'GRIT CATCHER')

SANITARY COLLECTION SYSTEM SANITARY COLLECTION SYSTEM

The pipe system for collecting and carrying liquid and liquid carried wastes from domestic sources to a wastewater treatment plant. (See 'WASTEWATER COLLECTION SYSTEM').

SANITARY SEWER SANITARY SEWER

A sewer that carries water and water carried wastes from residences, commercial buildings, industrial plants, and institutions, together with minor quantities of ground, storm, and surface waters that are not admitted intentionally.

SATURATED SOIL SATURATED SOIL

Soil that has its interstices or void spaces filled with water to the point at which runoff occurs.

SCALE SCALE

A combination of mineral salts and bacterial accumulation that adheres to the inside of a collection pipe under certain conditions. Scale, in extreme growth circumstances, creates additional friction loss to the flow of water. Scale may accumulate on surfaces other than pipes too.

SCOOTER SCOOTER

A sewer cleaning tool whose cleansing action depends on the development of high water velocity around the outside edge of a circular shield. The metal shield is rimmed with a rubber coating and is attached to a framework on wheels (like a child's scooter). The angle of the shield is controlled by a chain-spring system which regulates the head of water behind the scooter and thus, the cleansing velocity of the water flowing around the shield.

SCUM SCUM

(1) The layer or film of foreign matter that rises to the surface of water or wastewater and is formed there.

(2) A residue deposited on the ledge of a sewer, channel, or wet well at the water surface.

(3) A mass of solid matter that floats on the surface.

SEAL SEAL

(See 'PIPE JOINT SEAL')

SEALING SEALING

(See 'CHEMICAL GROUTING')

SEASONAL WATER TABLE SEASONAL WATER TABLE

A ground water table that has seasonal changes in depth or elevation.

SEDIMENT SEDIMENT

Solid material settled from suspension in a liquid.

SEDIMENTATION (SED-i-men-TAY-shun) SEDIMENTATION

The process of settling and depositing suspended matter carried by wastewater, by gravity. Sedimentation usually occurs when the velocity of the wastewater is reduced below the point at which it can transport the suspended material.

SEISMIC (SIZE-mick) SEISMIC

Having source from fault line stress or earthquake.

SELECT BACKFILL SELECT BACKFILL

Material used in backfilling of an excavation, selected for desirable compaction or other characteristics.

SEPTIC (SEP-tick) SEPTIC

A condition produced by the growth of anaerobic organisms. If severe, the wastewater turns black, giving off foul odors and creating a high oxygen demand.

SEPTIC TANK
SEPTIC TANK

A settling tank in which settled sludge is in intimate contact with the wastewater flowing through the tank and the organic solids are decomposed by anearobic bacterial action.

SERVICE
SERVICE

Any individual person, group of persons, thing, or group of things served with water through a single pipe, gate, valve, or similar means of transfer from a main distribution system. Also see 'BUILDING SERVICE'.

SERVICE CONNECTION
SERVICE CONNECTION

(See 'BUILDING SEWER')

SERVICE ROOT
SERVICE ROOT

A root entering the sewer system in a service line and growing down the pipe and into the sewer main.

SEWAGE
SEWAGE

The used water and water-carried solids from homes that flow in sewers to a treatment plant. The preferred term is WASTEWATER.

SEWER
SEWER

A pipe or conduit that carries wastewater or drainage water. The term COLLECTION LINE is often used also.

SEWER BALL
SEWER BALL

A sprially grooved inflatable semi-hard rubber ball designed for hydraulic cleaning of sewer pipes. (See 'BALLING')

SEWER CLEANOUT SEWER CLEANOUT

A cleanout located in a sewer main for necessary rodding and cleaning. Usually such cleanouts are located at terminal pipe ends or beyond terminal manholes. Also called a 'FLUSHER BRANCH'.

SEWER GAS SEWER GAS

(1) Gas evolved in collection lines (sewers) that results from the decomposition of organic matter in the wastewater. When testing for gases found in sewers, test for lack of oxygen and also for explosive and toxic gases.

(2) Any gas present in the wastewater collection system, even though it is from such sources as gas mains, gasoline, and cleaning fluid.

SEWER JACK SEWER JACK

A device placed in manholes which supports a yoke or pulley that keeps wires or cables from rubbing against the inlet or outlet of a sewer.

SEWER MAIN SEWER MAIN

Also called a collection main. A sewer pipe to which building laterals are connected.

SEWER SYSTEM SEWER SYSTEM

(See 'COLLECTION SYSTEM')

SEWERAGE SEWERAGE

System of piping with appurtenances for collecting, conveying and treating wastewater from source to discharge.

SHEAVE (SHE-v) SHEAVE

V-belt drive pulley which is commonly made of cast iron or steel.

SHEETING SHEETING

Solid material, such as wooden sheets or metal plates, used to hold back soil and prevent cave-ins.

SHIELD SHEILD

(1) A fabricated protective crib made of steel or aluminum plate that is placed on the bottom of open trenches to install or repair pipelines protecting the workers in unstable soil areas where conventional protective shoring is not sufficient.

(2) A device used to protect workers from sources of electrical, mechanical, or heat energy.

SHIM SHIM

Thin metal sheets which are inserted between two surfaces to align or space surfaces correctly. Can be used anyplace where a spacer is needed. Usually shims are 0.001 to 0.020 inches thick.

SHORING SHORING

Material such as boards, planks or plates and hydraulic jacks used to hold back soil around trenches and to protect workers in a trench from cave-ins.

SILTING **SILTING**

Silting takes place when infiltrating waters are able to achieve velocities to carry silt, sand and other small particles from the soil and into the sewer system. Where lower velocities are present in the sewer pipes, settling of these soils results in silting of the sewer system.

SINK **SINK**

(See 'DIP')

SIPHON **SIPHON**

A closed conduit a portion of which lies above the hydraulic grade line, resulting in a pressure less than atmospheric and requiring a vacuum within the conduit to start flow. A siphon uses atmospheric pressure to effect or to increase the flow of water through the conduit.

SLEEVE **SLEEVE**

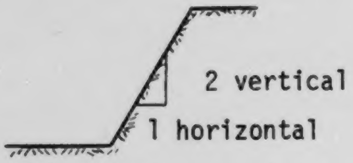
(1) A pipe fitting for uniting two pipes of the same nominal diameter in a straight line.

(2) A tube into which a pipe is inserted.

(3) A device to protect a shaft at its bearing or wear points.

SLOPE **SLOPE**

The slope or inclination of a sewer or trench excavation is given as the vertical to the horizontal or 'rise over run'. (See 'GRADE (2)')



2:1 slope

SLUDGE (sluj) SLUDGE

The settleable solids separated from liquids during processing or accumulated deposits on the bottom and edges of wastewater collection lines and appurtenances.

SMOKE TEST SMOKE TEST

A method of blowing smoke into a closed off section of a sewer system to locate sources of surface inflow.

SNAKE SNAKE

A stiff, flexible cable that is inserted into sewers to clear stoppages.

SOAP CAKE OR SOAP BUILD UP SOAP CAKE OR SOAP BUILD UP

A combination of detergents and greases that accumulate in sewer systems and build up over a period of time to cause severe restrictions.

SOIL DISPLACEMENT SOIL DISPLACEMENT

Generally accompanies SILTING of a sewer system. Where infiltration is taking place and silt is carried into a sewer system, such silt or soil is removed from the ground around the sewer pipe and the result is soil displacement.

SOIL PIPE SOIL PIPE

(1) A type of wastewater or service connection pipe made of a low grade of cast iron.

(2) In plumbing, a pipe that conveys the discharge of water closets or fixtures having similar functions, with or without the discharges from other fixtures.

SOIL POLLUTION SOIL POLLUTION

A condition which can take place where raw wastewater is exfiltrating into soil or ground area around a sewer pipe.

SOIL STABILIZATION SOIL STABILIZATION

Injecting chemical grouts into saturated or otherwise unstable soil. The method seals out water and prevents further instability.

SOUNDING ROD SOUNDING ROD

A T-shaped tool or shaft that is pushed or driven down through the soil to locate underground pipes and utility conduits. Also see 'PROBE'.

SPECIFIC GRAVITY SPECIFIC GRAVITY

Weight of a particle or substance in relation to the weight of an equal volume of water. Water has a specific gravity of 1.000 at 4°C (or 39°F). Wastewater particles or substances usually have a specific gravity of 0.8 to 2.6.

SPHERULITIC (SFEAR-you-LIT-tick) SPHERULITIC

A rounded aggregate or crystals in the form of a ball.

SPOIL SPOIL

Excavated material such as soil from the trench of a sewer.

STATIC HEAD STATIC HEAD

When water is not moving, the vertical distance (in feet) from a point to the water surface. Also see DYNAMIC HEAD.

STATION STATION

A point of reference or location in a pipeline is sometimes called a "station". As an example, a building service located fifty-one feet downstream from a manhole could be reported to be at "station fifty-one".

STATION, LIFT STATION, LIFT

(See 'LIFT STATION')

STILLING WELL STILLING WELL

A pipe, chamber, or compartment with a relatively small inlet or inlets connected to a main body of water, such as water in a wet well. The purpose of a stilling well is to dampen waves or surges while allowing the water level within the well to rise and fall with the major fluctuations of the main body of water. It is used with water measuring flow and depth devices to improve the accuracy of measurement.

STOPPAGE STOPPAGE

(1) When a sewer system becomes plugged and the flow backs, up, it is said to have a 'stoppage'.

(2) The place and cause of a stoppage. Example: "Fifty-one feet from a specific manhole" and "a grease stoppage".

(3) Partial or complete interruption of flow as a result of some obstruction in a sewer.

STORM COLLECTION SYSTEM STORM COLLECTION SYSTEM

A system of gutters, catch basins, yard drains, culverts and pipes for the purpose of conducting storm waters from an area, but intended to exclude domestic and industrial wastes.

STORM RUNOFF STORM RUNOFF

That portion of the total runoff that reaches the point of measurement within a relatively short period of time after the occurrence of precipitation. Also called DIRECT RUNOFF.

STORM SEWER STORM SEWER

A sewer that carries storm water and surface water, street wash and other wash waters, or drainage, but excludes domestic wastewater and industrial wastes. Also called STORM DRAIN.

STORM WATER STORM WATER

The excess water running off from the surface of a drainage area during and immediately after a period of rain. It is that portion of the rainfall and resulting surface flow in excess of that which can be absorbed through the infiltration capacity of the surface of the basin. See STORM RUNOFF.

STORM WATER INLET STORM WATER INLET

A device that admits surface waters to the storm water drainage system. Also see 'CURB INLET' and 'CATCH BASIN'.

STRINGERS STRINGERS

Horizontal shoring members, usually square, rough cut timber, that are used to hold solid sheeting, braces or vertical shoring members in place. See WALERS.

STRUCTURAL DEFECT STRUCTURAL DEFECT

A defect of structure or design which was built into a project, pipeline or other collection system appurtenance.

STRUCTURAL FAILURE STRUCTURAL FAILURE

A structural defect achieved as a result of a failure after completion of construction.

SUBSOIL GEOLOGY SUBSOIL GEOLOGY

The study of soil conditions existing below the surface of the ground at any selected site.

SUBSYSTEM SUBSYSTEM

An extensive underground sewer system connected to the main collection system, but not deemed part of the main system. An example might be the underground sewer system of a mobile home park.

SUCKER RODS SUCKER RODS

Rigid coupled sewer rods of metal or wood. Usually in 3 ft, 39 in, 4 ft, 5 ft and 6 ft lengths.

SUCTION HEAD SUCTION HEAD

The pressure (in feet or pounds per square inch (psi)) on the suction side of a pump. The pressure can be measured from the center line of the pump up to the elevation of the hydraulic grade line on the suction side of the pump.

SUCTION LIFT

SUCTION LIFT

The negative pressure (in feet or inches of mercury vacuum) on the suction side of a pump. The pressure can be measured from the center line of the pump down to the elevation of the hydraulic grade line on the suction side of the pump.

SURCHARGE

SURCHARGE

Sewers are surcharged when the surface of the wastewater in manholes is above the top of the sewer pipe. The sewer is under pressure or a head, rather than at atmospheric pressure.

SURCHARGED MANHOLE

SURCHARGED MANHOLE

A manhole in which the rate of the water entering is greater than the capacity of the outlet under gravity flow conditions. When the water in the manhole rises above the top of the outlet pipe, the manhole is said to be 'surcharged'.

SURFACE RUNOFF

SURFACE RUNOFF

(1) That portion of the runoff of a drainage basin that has not passed beneath the surface after deposition.

(2) The water that reaches a stream by traveling over the soil surface or falls directly into the stream channels, including not only the large permanent streams but also the tiny rills and rivulets.

(3) Water that remains after infiltration, interception, and surface storage have been deducted from precipitation.

SURFACED DEFECT

SURFACED DEFECT

A break or opening in a sewer pipe where the covering soil has been washed into a point where the opening or break is exposed on the ground surface.

SURFACED VOID

SURFACED VOID

Where silting has taken place to a degree that a void is caused in the subsoil and through successive cave-ins, the void reaches the surface of the ground.

SURVEILLANCE TELEVISION EQUIPMENT

SURVEILLANCE TELEVISION EQUIPMENT

Economical closed circuit television equipment designed for surveillance or security work in commercial facilities. Picture resolutions generally range from 250 to 350 lines.

SUSPENDED SOLIDS

SUSPENDED SOLIDS

Solids that either float on the surface of, or are in suspension in water, wastewater, or other liquids, and which are largely removable by laboratory filtering.

TAG LINE

TAG LINE

A line, rope or cable that follows equipment through a sewer so the equipment can be pulled back out if it encounters an obstruction or becomes stuck. Equipment is pulled forward with a pull line.

TAP

TAP

A small hole in a sewer where a wastewater service line from a building is connected (tapped) into a lateral or branch sewer.

TELEMETERING EQUIPMENT

TELEMETERING EQUIPMENT

Equipment that translates physical measurements into electrical impulses that are transmitted to dials or recorders.

TELEMETRY TELEMETRY

The practice of transmitting and receiving a metered variable.

TELEVISION INSPECTION TELEVISION INSPECTION

An inspection of the inside of a sewer pipe made by pulling a closed circuit television camera through the pipe.

TELEVISION INSPECTION LOG TELEVISION INSPECTION LOG

A record of a pipeline television inspection which provides date, line location, footage distances, pipe quadrant locations and descriptions of all conditions observed in the inspection. When this log is written, it is called a "WRITTEN RECORDING". When it is voice recorded on a tape, it is called a "VOICE TAPE RECORDING". Where the picture is recorded with a video tape recorder with audio remarks, it is called a "VIDEO-VOICE INSPECTION RECORD". Where data-view reporting is used, it is called a "VIDEO LOG".

TELEVISION MONITOR TELEVISION MONITOR

The television set or Kinescope where the picture is viewed on a closed circuit system.

TEMPORARY GROUND WATER TABLE TEMPORARY GROUND WATER TABLE

(1) During and for a period following heavy rainfall or snow melt, the soil is saturated at elevations above the normal, stabilized or seasonal ground water table, often from the surface of the soil downward. This is referred to as a temporary condition and thus is a 'temporary ground water table'.

(2) Where a collection system has agricultural areas in its vicinity, irrigation of these areas can cause a temporary rise in the elevation of the ground water table.

TERMINAL CLEANOUT TERMINAL CLEANOUT

Where a manhole is not provided at the upstream terminal of a sewer main, a cleanout is usually provided. This is called a 'terminal cleanout' or a 'flusher branch'.

TERMINAL MANHOLE TERMINAL MANHOLE

A manhole located at the upstream end of a sewer and having no inlet pipe. Also called a 'DEADEND MANHOLE'.

TEST BORE TEST BORE

A hole or bore made to sample and determine the structure of underground soil conditions.

TIDE GATE TIDE GATE

A gate with a flap suspended from a free-swinging horizontal hinge, usually placed at the end of a conduit discharging into a body of water having a fluctuating surface elevation. The gate is usually closed because of outside water pressure, but will open when the water head inside the pipe is large enough to overcome the outside pressure, the weight of the flap, and the friction of the hinge. Also called a BACKWATER GATE.

TOPOGRAPHIC GEOLOGY TOPOGRAPHIC GEOLOGY

A study of the rock and soil formations of an area for purposes of mapping underground conditions with identifications and elevations. Often called a "Geological Survey".

TOPOGRAPHY (toe-POG-gra-fee) TOPOGRAPHY

The description or features of an area, such as the hills, valleys, mountains and slope of the land surfaces.

TOTAL CONTRIBUTION TOTAL CONTRIBUTION

The total contribution entering a sewer system from a specific facility, subsystem or area. This includes domestic and industrial wastewaters, inflow and infiltration reaching the main collection system.

TOTAL FLOW TOTAL FLOW

The total gallonage of flow during a specified period of measurement and passing a selected point of measurement in the collection system.

TOTAL DYNAMIC HEAD (T.D.H.) TOTAL DYNAMIC HEAD

When a pump is lifting or pumping water, the vertical distance (in feet) from the elevation of the energy grade line on the suction side of the pump to the elevation of the energy grade line on the discharge side of the pump.

TOTALIZER TOTALIZER

A totalizer continuously sums or adds up the flow past the meter in gallons or million gallons or some other unit of measurement. Also called an integrator.

TRAP TRAP

(1) In a wastewater collection system of a building, plumbing codes require every drain connection from an appliance or fixture to have a trap. The trap in this case is a gooseneck that holds water to prevent vapors or gases from a collection system from entering the building.

(2) Various other types of special traps are used in collection systems such as a "GRIT TRAP" or "SAND TRAP".

TRAP, DIP TRAP, DIP

(See 'DIP')

TRAP, HANDHOLE TRAP, HANDHOLE

(See 'HANDHOLE TRAP')

TRENCH JACK TRENCH JACK

Mechanical screw device used to hold shoring in place.

TRUNK SEWER TRUNK SEWER

A sewer that receives many tributary branches and serves a large territory. See MAIN SEWER.

TRUNK SYSTEM TRUNK SYSTEM

A system of major sewers serving as transporting lines and not as local or lateral sewers.

TURBIDITY TURBIDITY

(1) A condition in water or wastewater caused by the presence of suspended matter, resulting in the scattering and absorption of light rays.

(2) An analytical quantity usually reported in arbitrary turbidity units determined by measurements of light diffraction.

TWO-WAY CLEANOUT TWO-WAY CLEANOUT

A cleanout designed for rodding or working a snake into a pipe in either direction. Most often application is in building lateral pipes at or near to a property line.

U-TUBE U-TUBE

(1) A pipe shaped like a U that is constructed in a force main to raise the dissolved oxygen concentration in the wastewater.

(2) U-tube manometers are used to indicate the pressure of a gas or liquid in a confined space.

UNDERMINED UNDERMINED

(1) A condition where the bedding support under a pipe or manhole is removed or washed away. Conditions leading to or causing this are believed to be the presence of excess water during backfill. Other causes are horizontal boring operations, excavations adjacent to the pipe or manhole and exfiltration or infiltration at drop joints.

(2) Where a broken section of pipe is carrying away soil, leaving a void, the surfaces are said to be 'undermined'.

UNDISTURBED SOIL UNDISTRUBED SOIL

Soil, at any depth, which has not been excavated or disturbed by excavation or construction.

UPRIGHTS UPRIGHTS

Vertical shoring members that may be solid (SHEETING) or spaced from 2 to 8 feet apart to prevent cave-ins.

UPSTREAM UPSTREAM

The direction against the flow of water or toward or in the higher part of a sewer or collection system.

V-NOTCH WEIR V-NOTCH WEIR

A triangular weir with a "V" notch calibrated in gallons per minute readings. By holding the weir in a pipe with rubber seals forcing a flow to pass through the "V", a measure of the gallonage flowing through the pipe can be read on the basis of the depth of water flowing over the weir.

VAC-ALL VAC-ALL

Equipment that removes solids from a manhole as they enter the manhole from a hydraulic cleaning operation. Most of the wastewater removed from the manhole by the operation is separated from the solids and returned to the sewer.

VEGETABLE WASTES VEGETABLE WASTES

Vegetable matter entering a collection system. This term is usually applied to differentiate such types of waste from animal, industrial, commercial and other types of waste solids.

VEHICLE, LIQUID VEHICLE, LIQUID

(See 'LIQUID VEHICLE')

VELOCITY HEAD VELOCITY HEAD

A vertical height (in feet) equal to the square of the velocity of flowing water divided by twice the acceleration due to gravity ($V^2/2g$).

VENTS, MANHOLE VENTS, MANHOLE

(See 'MANHOLE VENTS')

VENTS, WASTELINE SYSTEM VENTS, WASTELINE SYSTEM

(See 'WASTELINE VENTS')

VERTICAL OFFSET VERTICAL OFFSET

A pipe joint where one section is connected to another at a different elevation, such as, a DROP JOINT.

VIDEO INSPECTION VIDEO INSPECTION

A television inspection.

VIDEO LOG VIDEO LOG

A magnetic tape picture recording of a television inspection where data-view reporting has been included as part of the visual record.

VIDEO TAPE VIDEO TAPE

A magnetic tape for recording television pictures. Standard tapes also have a capacity to record a voice with the picture, or an 'audio' accompanyment.

VOID VOID

A pore or open space in rock or granular material, not occupied by solid matter. It may be occupied by air, water, or other gaseous or liquid material. Also called interstice or void space.

VOLTAGE VOLTAGE

The electrical pressure available to cause a flow of current (amperage) when an electrical circuit is closed. See ELECTROMOTIVE FORCE (E.M.F.)

VOLUTE (vol-LOOT) VOLUTE

The spiral-shaped casing surrounding a pump impeller that collects the water discharged by the impeller.

WALERS (WAY-lers) WALERS

Horizontal shoring members, usually square, rough cut timber, that are used to hold solid sheeting, braces or vertical shoring members in place. See STRINGERS.

WASTELINE CLEANOUT WASTELINE CLEANOUT

A point of access in a building wastewater pipe system for rodding or snake operation.

WASTELINE SYSTEM WASTELINE SYSTEM

(See 'BUILDING WASTEWATER COLLECTION SYSTEM')

WASTELINE TRAP WASTELINE TRAP

(See 'TRAP (1)')

WASTELINE VENT WASTELINE VENT

Most plumbing codes require a vent pipe connection of adequate size and located downstream of a trap in a building wastewater system. This vent serves to prevent accumulations of gases or odors and is usually piped through the roof and out of doors.

WASTEWATER WASTEWATER

The used water and water-carried solids from a community that flow to a treatment plant. Storm water, surface water, and ground water infiltration also must be included in the wastewater that enters a plant. The term SEWAGE usually refers to household wastes, but this word is being replaced by the term wastewater.

WASTEWATER COLLECTION SYSTEM WASTEWATER COLLECTION SYSTEM

The pipe system for collecting and carrying water and water-carried wastes from domestic and industrial sources to a wastewater treatment plant.

WASTEWATER FACILITIES WASTEWATER FACILITIES

The pipes, conduits, structures, equipment, and processes required to collect, transport, and treat domestic and industrial wastes, and dispose of the effluent.

WASTEWATER TREATMENT PLANT WASTEWATER TREATMENT PLANT

(1) An arrangement of pipes, equipment, devices, tanks and structures for treating wastewater, industrial wastes, and sludge.

(2) A water pollution control plant.

WATER TABLE WATER TABLE

(See 'GROUND WATER TABLE')

WATER TABLE DEPTH WATER TABLE DEPTH

(See 'GROUND WATER DEPTH')

WATER TABLE ELEVATION WATER TABLE ELEVATION

(See 'GROUND WATER ELEVATION')

WATER TABLE HEAD WATER TABLE HEAD

(See 'PRESSURE HEAD')

WAYNE BALL WAYNE BALL

A spirally grooved, inflatable, semi-hard rubber ball designed for hydraulic cleaning of sewer pipes. See 'BALLING' and 'SEWER BALL'.

WELL POINT WELL POINT

A perforated metal tube or screen attached to a jetting or driving head end, designed to permit the entrance of water. A well point is jetted or driven into place.

WET PIT WET PIT

See Wet Well

WET WELL WET WELL

A compartment or room in which wastewater is collected, and to which the suction pipe of a pump may be connected. Also a submersible pump may be located in a wet well.

WICK EFFECT WICK EFFECT

(See 'CAPILLIARY EFFECT')

"Y" CONNECTION "Y" CONNECTION

Another name for a 'BUILDING SERVICE'.

ZONE OF SATURATION ZONE OF SATURATION

(1) Where raw wastewater is exfiltrating from a sewer pipe, the area of soil around the leak point that is moistened is often called the 'zone of saturation'.

(2) The area of soil saturated with water.

APPENDIX M

APPLICATIONS OF ARITHMETIC TO COLLECTION SYSTEMS

by

Kenneth D. Kerri

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OBJECTIVES

Appendix M. Applications of Arithmetic to Collection Systems

After completion of Appendix M, you should be able to do the following:

1. Do simple addition, subtraction, multiplication and division.
2. Calculate perimeters, circumferences, areas and volumes.
3. Analyze mathematical problems and solve them.
4. Solve collection system problems regarding:
   a. Excavations and Paving,
   b. Chemical doses,
   c. Electricity,
   d. Costs,
   e. Hydraulics,
      1) Slopes
      2) Velocities
      3) Flow rates
      4) Wet wells
      5) Pumps
   f. Maps and blueprints.

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APPENDIX M. APPLICATIONS OF ARITHMETIC TO COLLECTION SYSTEMS

M.1 WHY ARITHMETIC?

Actually most collection system workers use very little arithmetic when doing their day-to-day jobs. If you can add, subtract, multiply and divide, you can solve all of the problems in this appendix. An electronic calculator can do the addition, subtraction, multiplication and division for you if you can write the formula or equation to be solved. Slide rules can do multiplication and division.

Collection system workers need to know arithmetic in order to calculate slopes of trenches or pipes and also velocities and flows in sewers. Other examples of uses of arithmetic include the determination of proper chemical doses to control roots or odors. When estimating the cost of a sewer repair job, the costs must be calculated for budgeting purposes. To order bedding or backfill material, the appropriate quantities have to be determined so there are not unnecessary delays from insufficient materials or excess material remaining when the job is completed. Calculations are important when calibrating and comparing performance of new pumps and flow meters with specifications. From time to time equipment performance must be reverified. As you can see, periodically certain jobs that collection system workers must do require some knowledge of and ability to do simple arithmetic. After you have worked an actual collection system arithmetic problem in the field, you should verify your calculations, examine your answer to see if it appears reasonable, and if possible, have another worker review your work before taking any action.

In this appendix we have tried to show you how to solve problems actually encountered by collection system workers in the field. Hopefully, questions on certification and civil service exams will not be any more difficult.

An objective of this appendix is to provide you with a quick review of some basic arithmetic principles and examples of typical collection system problems. This appendix is not intended to be an arithmetic textbook. Some workers will be able to skip over the review section on addition, subtraction, multiplication and division. Others may need more help in these and other areas. Basic arithmetic textbooks are available

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at every local library or bookstore and can be referred to if needed. Deserving special mention is Mathematics for Water and Wastewater Treatment Plant Operators[1] which provides considerable detail on how to do basic calculations.

M.2 BASIC CALCULATIONS[2]

M.20 Addition

Not many people will make a mistake when adding 2 plus 2. However, it is surprising how many cannot correctly add 22.222 and 0.0022. The reason is they violate one of the main rules of addition or subtraction, and that is:

1. KEEP ALL DECIMAL POINTS AND NUMBERS IN COLUMNS

   When the rule is followed correctly, the above addition is easily performed.

$$\begin{array}{r} 22.222 \\ +\ \ 0.0022 \\ \hline 22.2242 \end{array}$$

Another common error is made in the following manner:

$$\begin{array}{rl} 349 & \\ +\ \ 75 & \\ \hline 414 & \text{(Wrong)} \end{array}$$

In this case another rule is violated.

---

[1] Mathematics for Water and Wastewater Treatment Plant Operators, Book 1 - Fundamentals and Book 2 - Advanced, by Joanne Kirkpatric, published by Ann Arbor Science Publishers Inc., P.O. Box 1425, Ann Arbor, Michigan 48106. Price $17.50 for each book.

[2] Major portions of this appendix are taken from Chapter 15, "Basic Mathematics and Treatment Plant Problems" by William Crooks in Operation of Wastewater Treatment Plants, Kenneth D. Kerri, California State University, Sacramento, 6000 Jay Street, Sacramento, CA 95819. Price for 17 chapter manual, $25.00.

2. WRITE DOWN ALL CARRYOVER NUMBERS

If this rule is followed, the previous problem becomes:

$$\begin{array}{rr} & {}^{/\,/} \\ & 349 \\ + & 75 \\ \hline & 424 \end{array}$$

Carryover numbers should be written lightly over the next column to the left.

Many students can remember a teacher saying to them, "You can't add apples and oranges." This is our third rule of addition.

3. ALL NUMBERS MUST BE IN THE SAME DIMENSIONAL UNITS (ft, lb, sec)

If we needed a string 2 feet long and one 6 inches long, we would either say:

2 ft + ½ ft = 2½ ft of string, or

$$\begin{array}{r} 2\ \text{ft} \\ \tfrac{1}{2}\ \text{ft} \\ \hline 2\tfrac{1}{2}\ \text{ft} \end{array}$$

or we might say:

24 inches + 6 inches = 30 inches of string, or

$$\begin{array}{r} 24\ \text{in} \\ 6\ \text{in} \\ \hline 30\ \text{in} \end{array}$$

Two and one-half feet and 30 inches are the same length. We must use the same dimensional units when we add any series of numbers.

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M.21 Subtraction

Since subtraction is simply the reverse of addition, the three rules for addition generally apply to subtraction:

1. KEEP ALL DECIMAL POINTS AND NUMBERS IN COLUMNS

   Example: Subtract 0.042 from 3.574.

$$\begin{array}{r} 3.574 \\ -\ \underline{0.042} \\ 3.532 \end{array}$$

Since subtraction is the reverse of addition, carryovers are not made, but "borrowing" is sometimes necessary.

2. WRITE DOWN ALL BORROWED NUMBERS

   Example: Subtract 296 from 485.

   As before, the numbers should be grouped in columns.

$$\begin{array}{r} {\scriptstyle 3\ 11\ 15} \\ 4\cancel{8}5 \\ -\underline{296} \\ 189 \end{array}$$

or

COLUMN LABELS

Hundreds	Tens	Units
4	8	5
-1	-1	+10
3	7	15
	+10	
	17	
-2	9	6
1	8	9

The following three steps explain how to subtract by both of the above methods.

1st Step - Borrow one from the eight (leaving seven) and add ten to the five to get 15 -- Subtract six from 15 and write down nine.

2nd Step - Borrow one from the four and add ten to the seven to get 17 -- subtract nine from 17 and write down eight.

3rd Step - Subtract two from three and write down one.

The best way to check a subtraction is by addition. Thus, the preceding problem can be checked by:

$$\begin{array}{r} \overset{/}{1}\overset{/}{8}9 \\ +\ 296 \\ \hline 485 \end{array} \quad \text{(check)}$$

The final rule of subtraction is the same as for addition.

3. ALL NUMBERS MUST BE IN THE SAME DIMENSIONAL UNITS (ft, lb, sec)

If we have a 3-foot section of pipe and cut off 6 inches, how much pipe is left?

3 ft - ½ ft = 2½ ft of pipe, or

$$\begin{array}{r} 3\text{ ft} \\ -\tfrac{1}{2}\text{ ft} \\ \hline 2\tfrac{1}{2}\text{ ft} \end{array}$$

Since 3 feet of pipe is the same as 36 inches of pipe, we could use the dimensional units of inches.

36 inches - 6 inches = 30 inches of pipe, or

$$\begin{array}{r} 36\text{ inches} \\ -\ 6\text{ inches} \\ \hline 30\text{ inches} \end{array}$$

Two and one-half feet of pipe is the same length as 30 inches of pipe. We must use the same dimensional units when we subtract numbers.

M.22 Multiplication

Multiplication is simply a short-cut method of addition. In other words, 3 x 4 is simply:

3 + 3 + 3 + 3 = 12

or 4 + 4 + 4 = 12

Thus a multiplication problem can always be checked by addition. In the interest of time, however, every worker should memorize the multiplication table through 10.

MULTIPLICATION TABLE THROUGH 10

	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	14	16	18	20
3	3	6	9	12	15	18	21	24	27	30
4	4	8	12	16	20	24	28	32	36	40
5	5	10	15	20	25	30	35	40	45	50
6	6	12	18	24	30	36	42	48	54	60
7	7	14	21	28	35	42	49	56	63	70
8	8	16	24	32	40	48	56	64	72	80
9	9	18	27	36	45	54	63	72	81	90
10	10	20	30	40	50	60	70	80	90	100

Multiplication problems involving larger numbers can be solved by addition also. For example, 24 x 17 can be solved by adding a column of seventeen 24's or a column of twenty-four 17's. This procedure, however, would take considerable time, and therefore the simple multiplication steps are preferred.

$$\begin{array}{r} \scriptstyle 2 \\ 24 \\ \times\ 17 \\ \hline 8 \end{array}$$

1st Step - 4 x 7 = 28 -- write down eight and carry the two to the next column.

$$\begin{array}{r} \scriptstyle 2 \\ 24 \\ \times\ 17 \\ \hline 168 \end{array}$$

2nd Step - 2 (from 2 in 24) x 7 = 14; 14 + 2 (carried 2) = 16 -- write down 16.

$$\begin{array}{r} 24 \\ \times\ 17 \\ \hline 168 \\ 4 \end{array}$$

3rd Step - Erase all carryovers. 4 x 1 = 4 -- write down four in second row, but one place to left.

$$\begin{array}{r} 24 \\ \times\ 17 \\ \hline 168 \\ 24 \end{array}$$

4th Step - 2 x 1 = 2 -- write down two.

$$\begin{array}{r} 24 \\ \times\ 17 \\ \hline 168 \\ 24 \\ \hline 408 \end{array}$$

5th Step - Add numbers.

Another approach to multiplication is the regrouping concept we illustrated in the subtraction section by placing the number in the appropriate hundreds (H), tens (T), and units (U) columns. The idea behind this approach is that

10 ones or 10 units (U) = 1 ten (T) = 10

and

10 tens or 10 tens (T) = 1 hundred (H) = 100

Problem: Multiply 24 x 17 or

```
  24
x 17
```

		H	T	U	
1st Step	7 x 4 =		2	8	= 28 units or 2T + 8U
2nd Step	7 x 2 =	1	4		Unit (7) times Ten (2) makes right digit (4) go in T column or 1H + 4T
3rd Step	1 x 4 =		4		T x U = the Tens column
4th Step	1 x 2 =	2			T x T = the Hundreds column
5. Add Columns		3	10	8	
6. Regroup		1			Since 10T = 1H
7. Answer		4	0	8	

To multiply numbers, you may use any method that you understand. These methods are presented to show you different approaches used by many workers which give the same answers.

The first important rule to remember in multiplication is:

1. THE NUMBER OF DECIMAL PLACES IN THE ANSWER IS EQUAL TO THE SUM OF DECIMAL PLACES IN THE NUMBERS MULTIPLIED

Example:

```
  14.032 ..........   3 decimal places
    1.03 .......... + 2 decimal places
   42096
   00000
  14032
14.45296 ..........   5 decimal places
```

Another way to determine the location of the decimal point is to multiply the numbers without the numbers past the decimal point. For example 14 x 1 = 14. Therefore, 14.032 x 1.03 must be equal to more than 14.

A basic difference between addition and multiplication is that the multiplied numbers do not have to have similar dimensional units.

2. NUMBERS DO NOT HAVE TO HAVE THE SAME DIMENSIONAL UNITS

For this reason it is important tc specify the units that go with the numbers and carry them through to the answer.

Example: A 20-pound weight on the end of an 8-foot lever would produce --

20 lbs x 8 ft = 160 ft-lbs

Example: Three men working five hours each would put in --

3 men x 5 hours = 15 man-hours of labor

The multiplication operation is indicated by several different symbols. The most common, of course, is the multiplication sign (x) or times sign. Multiplication also can be indicated by parentheses ( ) or by brackets [ ] or simply with a dot · . Thus the above example can be written five ways:

3 men x 5 hours = 15 man-hours

(3 men)(5 hours) = 15 man-hours

[3 men][5 hours] = 15 man-hours

3 men · 5 hours = 15 man-hours

(3 men) x 5 hours = 15 man-hours

When solving a problem with parentheses or brackets, always complete the indicated operation within the parentheses or brackets prior to performing the multiplication.

Example:

$$\begin{aligned} (25 - 4)\ (8 + 2)\ (3 \cdot 2) &= \\ (21)\quad (10)\quad (6) &= \\ 21 \times 10 \times 6 &= 1260 \end{aligned}$$

Example:

$$\begin{aligned} [15 - (3 + 2)\ (4 - 2)]\ [6 + (7 - 3)] &= \\ [15 - \quad (5) \quad (2)\ ]\ [6 + \quad 4\ ] &= \\ [15 \quad - \quad 10\ ]\ [\ 10\ ] &= \quad 50 \end{aligned}$$

M.23 Division

Division offers a means of determining how many times one number is contained in another. It is a series of subtractions. For example, if we say divide 48 by 12, we are also saying, how many times can we take 12 away from 48?

By subtraction:

$$\begin{aligned} 48 - 12 &= 36 \text{ (one)} \\ 36 - 12 &= 24 \text{ (two)} \\ 24 - 12 &= 12 \text{ (three)} \\ 12 - 12 &= 0 \text{ (four)} \end{aligned}$$

By division:

$$\begin{array}{r} 4 \\ 12\ \overline{)48} \end{array}$$

1st Step - Twelve will not divide into four, but will divide into 48 at least four times.

$$\begin{array}{r} 4 \\ 12\ \overline{)48} \\ \underline{48} \\ 0 \end{array}$$

2nd Step - Multiply 4 x 12 and write answer under 48. Remainder is zero. Answer is exactly four.

Division problems can be written in many ways:

$\begin{array}{r} 2 \\ 5\overline{)10} \end{array}$ $\qquad 10 \div 5 = 2 \qquad \frac{10^{*}}{5} = 2 \qquad 10/5 = 2$

In each case,

5 = divisor

10 = dividend

2 = quotient

It is always easier to divide by a whole number.

1. MOVE THE DECIMAL POINT OF THE DIVISOR ALL THE WAY TO THE RIGHT AND THE DECIMAL POINT OF THE DIVIDEND THE SAME NUMBER OF PLACES TO THE RIGHT

Example: Divide 1.25 by 0.045.

$\begin{array}{cc} \text{Divisor} & \text{Dividend} \\ \downarrow & \downarrow \\ 0.\underset{\curvearrowright}{045}. & \overline{)1.\underset{\curvearrowright}{250}} \end{array}$	1st Step - Move decimal point three places to right in divisor and dividend. To do this you must add one 0 to the dividend.
$\begin{array}{r} 2\ . \\ 45\overline{)1250.0} \end{array}$	2nd Step - Forty-five will not divide into one or 12, but will go into 125 about two times.
$\begin{array}{r} 2 \\ 45\overline{)1250.0} \\ \underline{-90} \\ 35 \end{array}$	3rd Step - Multiply 45 by 2 and subtract answer from 125.
$\begin{array}{r} 2 \\ 45\overline{)1250.0} \\ \underline{90\downarrow} \\ 350 \end{array}$	4th Step - Bring down zero.
$\begin{array}{r} 27 \\ 45\overline{)1250.0} \\ \underline{90} \\ 350 \end{array}$	5th Step - Forty-five will go into 350 about seven times.

---

*You will encounter this form in Section M.3 as a fraction.

$$\begin{array}{r} 27 \\ 45\overline{)1250.0} \\ \underline{90} \\ 350 \\ \underline{-315} \\ 35 \end{array}$$

6th Step - Multiply 45 by 7 and subtract answer from 350.

$$\begin{array}{r} 27.7 \\ 45\overline{)1250.0} \\ \underline{90} \\ 350\ | \\ \underline{315}\ \downarrow \\ 35\ 0 \end{array}$$

7th Step - Bring down zero. Once again, 45 will go into 350 about 7 times.

If this problem is continued, sevens will continue to show up in the answer. The answer, then, is 27.777, etc. In most cases 27.78 will be sufficiently accurate. This is called "rounding off" the numbers. The last number 7 was increased to 8 because the number after it was 5 or higher.

When solving a division problem, complete the indicated operations above and below the division line before dividing.

Example:

$$\frac{25 - (2)\,(3) + 18/2}{19 - (3)\,(4)} + \frac{(4)\,(9)}{12} - 5 =$$

1st Step

$(2)(3) = 6$

$18/2 = 9$

$(4)(9) = 36$

$(3)(4) = 12$

$$\frac{25 - 6 + 9}{19 - 12} + \frac{36}{12} - 5 =$$

2nd Step

$25 - 6 + 9 = 28$

$19 - 12 = 7$

$36/12 = 3$

$$\frac{28}{7} + 3 - 5 =$$

3rd Step

$\frac{28}{7} = 4$

$$4 + 3 - 5 = 2$$

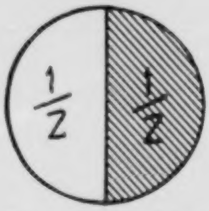
4th Step

$4 + 3 - 5 = 2$

M.3 FRACTIONS[3]

M.30 Parts of a Whole

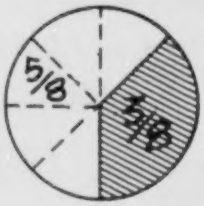
A fraction in its most common form is a part of a whole. For instance, if a pie is divided into two equal parts and one part is eaten, only one half of the pie remains.



1 - 1/2 = 1/2
and
1/2 + 1/2 = 1

Thus it can be seen that a fraction is division that has not been completed. As previously explained, in the fraction 1/2, one is the dividend and two is the divisor. More commonly, however, one is called the numerator and two is called the denominator.

If the pie were divided into eight equal pieces and five were eaten, we would have less than one half a pie. We would have 3/8 of a pie remaining.



1 - 5/8 = 3/8
and
5/8 + 3/8 = 1

M.31 Improper Fraction

An improper fraction has a larger numerator than denominator and is therefore greater than one. An improper fraction may be reduced to a whole or mixed number by dividing the denominator into the numerator.

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[3] Most collection system problems can be solved without a thorough understanding of fractions. This section is provided to help you with fractions and to help you understand percentages and efficiencies.

Example: $\frac{13}{8}$ (numerator) (denominator) $= \begin{array}{r} 1 \\ 8/\overline{13} \\ -8 \\ 5 \end{array} = 1\frac{5}{8}$

The reverse of this operation would be changing a whole or mixed number into a fraction. To accomplish this the whole number is multiplied by the denominator, the numerator is added, and this total is written over the denominator.

Example: $2\ 1/4 = \frac{4 \times 2 + 1}{4}$

$= \frac{8 + 1}{4}$

$= \frac{9}{4}$

M.32 Reducing a Fraction to Lowest Terms

To change a fraction to its lowest terms, divide the numerator and denominator by the largest number that will divide evenly into both:

Example: $\frac{15}{45} = \frac{15 \div 15}{45 \div 15} = \frac{1}{3}$

NOTE: At this point it should be remembered that the numerator and denominator can be divided or multiplied by the same number without changing the value of the fraction.

Sometimes it will not be possible to reduce the fraction to its lowest terms with the first trial division. In this case, division continues until it can no longer be performed by a number larger than one.

Example: $\frac{216}{324} = \frac{216 \div 3}{324 \div 3} = \frac{72}{108} = \frac{72 \div 9}{108 \div 9} = \frac{8}{12} = \frac{8 \div 4}{12 \div 4} = \frac{2}{3}$

In solving this problem all of these steps could have been eliminated if we had realized that 108 will divide into the numerator twice and into the denominator three times. This is usually difficult to see, however, and smaller numbers must be used as trial divisors.

M.33 Adding and Subtracting

Whenever fractions are added or subtracted it is necessary that the denominators be the same. In adding or subtracting fractions, you simply add or subtract numerators and reduce the fraction to its lowest terms.

Example: $\frac{3}{5} + \frac{4}{5} = \frac{7}{5} = 1\frac{2}{5}$

Example: $\frac{7}{8} - \frac{3}{8} = \frac{4}{8} = \frac{1}{2}$

If the denominators are not the same, they must be made the same before addition or subtraction takes place. In changing the form of a fraction, the numerator and denominator must be multiplied by the same number.

Example: $\frac{3}{5} + \frac{5}{10} = \frac{3(2)}{5(2)} + \frac{5}{10} = \frac{6}{10} + \frac{5}{10} = \frac{11}{10} = 1\frac{1}{10}$

Example: $\frac{2}{3} - \frac{4}{9} = \frac{2(3)}{3(3)} - \frac{4}{9} = \frac{6}{9} - \frac{4}{9} = \frac{2}{9}$

In some cases the denominators cannot be changed to one of the problem's existing denominators. For instance, in adding 1/3 and 1/4, the 1/3 can't be changed to an even fourth, and the 1/4 can't be changed to an even third. In this case, they must both be changed to the least common denominator. The least common denominator is the smallest number that each denominator will go into one or more times without a remainder.

Example: $\frac{1}{3} + \frac{1}{4}$

The lowest number that both 3 and 4 will both go into is 12. Three will go into twelve 4 times; four will go into twelve 3 times.

Therefore, the least common denominator is 12. We obtained 12 by multiplying 3 x 4.

$$\frac{1 \times 4}{3 \times 4} + \frac{1 \times 3}{4 \times 3} = \frac{4}{12} + \frac{3}{12} = \frac{7}{12}$$

M.34 Multiplication

Multiply all of the numerators together for a new numerator, and multiply all of the denominators together for a new denominator. In multiplication, denominators need not be the same.

Example: $\frac{5}{7} \times \frac{2}{4} = \frac{10}{28} = \frac{5}{14}$

Before multiplying mixed numbers, change the mixed numbers to improper fractions:

Example: $2\frac{1}{2} \times \frac{2}{5} = \frac{5}{2} \times \frac{2}{5} = \frac{10}{10} = 1$

In some cases a problem can be simplified by dividing (or canceling) prior to beginning the multiplication. This operation also speeds up the process of reducing the answer to its simplest form. To reduce numbers by cancellation, look for a number in the numerator and denominator that can be divided by the same number.

Example: $\frac{2}{3} \times \frac{3}{4} \times \frac{1}{5} = ?$

$$\frac{\overset{1}{\cancel{2}}}{\underset{1}{\cancel{3}}} \times \frac{\overset{1}{\cancel{3}}}{\underset{2}{\cancel{4}}} \times \frac{1}{5} = \frac{1}{10}$$

(2 goes into 2--1 time)
(2 goes into 4--2 times)
(3 goes into 3--1 time)
(3 goes into 3--1 time)

Example - the same problem without cancellation:

$$\frac{2}{3} \times \frac{3}{4} \times \frac{1}{5} = \frac{6}{60} = \frac{1}{10}$$

Another example of cancellation:

$$\frac{\overset{3}{\cancel{9}}}{\underset{4}{\cancel{28}}} \times \frac{\overset{5}{\cancel{35}}}{\underset{8}{\cancel{24}}} = \frac{3}{4} \times \frac{5}{8} = \frac{15}{32}$$

(3 goes into 9 and 24)
(7 goes into 28 and 35)

M.35 Division

To divide two fractions, invert* the divisor and multiply.

Example: $\frac{1}{2} \div \frac{1}{3} = \frac{1}{2} \times \frac{3}{1} = \frac{3}{2} = 1\frac{1}{2}$

Example: $\frac{5}{6} \div \frac{3}{12} = \frac{5}{\underset{1}{\cancel{6}}} \times \frac{\overset{2}{\cancel{12}}}{3} = \frac{10}{3} = 3\frac{1}{3}$

M.36 Decimal Fractions

Decimal fractions are fractions which have 10, 100, 1000, etc., for denominators. They are usually called decimals.

$\frac{5}{10}$ = 0.5 = five-tenths

$\frac{15}{100}$ = 0.15 = fifteen-hundredths

$375\frac{25}{1000}$ = 375.025 = three hundred seventy-five and twenty-five thousandths

or = three hundred seventy-five point zero two five

To change any fraction to a decimal, divide the numerator by the denominator.

Example: $\frac{3}{4} = 3 \div 4 = $

$$\begin{array}{r} 0.750 \\ 4\overline{)3.000} \\ \underline{2\,8} \\ 20 \\ \underline{20} \\ 0 \end{array}$$

Example: $\frac{5}{6} = 5 \div 6 = $

$$\begin{array}{r} 0.833 \\ 6\overline{)5.000} \\ \underline{4\,8} \\ 20 \\ \underline{18} \\ 20 \\ \underline{18} \\ 2 \end{array}$$

. . . (not even)

---

*Invert means turn over as when you invert $\frac{1}{3}$, you get $\frac{3}{1}$.

To change a decimal to a fraction, multiply the decimal by 10/10, 100/100, 1000/1000, etc. It should be noted that multiplying by these factors is multiplying by one (100/100 = 1) and does not change the value of the answer.

Example: $0.25 \times \frac{100}{100} = \frac{25}{100} = \frac{1}{4}$

Example: $0.375 \times \frac{1000}{1000} = \frac{375}{1000} = \frac{15}{40} = \frac{3}{8}$

M.37 Percentage

Expressing a number in percentage is just another, and sometimes simpler, way of writing a fraction or a decimal. It can be thought of as parts per 100 parts, since the percentage is the numerator of a fraction whose denominator is always 100. Twenty-five parts per 100 parts is more easily recognized as 25/100 or 0.25. However, it is also 25%. In this case, the symbol % takes the place of the 100 in the fraction and the decimal point in the decimal fraction.

For the above example it can be seen that changing from a fraction or a decimal to percent is not a difficult procedure.

1. To change a fraction to percent, multiply by 100%.

   Example: $\frac{2}{5} \times 100\% = \frac{200\%}{5} = 40\%$

   Example: $\frac{5}{4} \times 100\% = \frac{500\%}{4} = 125\%$

2. To change percent to a fraction, divide by 100%.

   Example: $15\% \div 100\% = 15\% \times \frac{1}{100\%} = \frac{15}{100} = \frac{3}{20}$

   Example: $0.4\% \div 100\% = 0.4\% \times \frac{1}{100\%} = \frac{.4}{100} = \frac{4}{1000} = \frac{1}{250}$

   In these examples note that the two percent signs cancel each other.

Following is a table comparing common fractions, decimal fractions, and percent to indicate their relationship to each other:

Common Fraction	Decimal Fraction	Percent
$\frac{285}{100}$	2.85	285%
$\frac{100}{100}$	1.0	100%
$\frac{20}{100}$	0.20	20%
$\frac{1}{100}$	0.01	1%
$\frac{1}{1000}$	0.001	0.1%
$\frac{1}{1,000,000}$	0.000001	0.0001%

M.38 Sample Problems Involving Percent

Problems involving percent are usually not complicated since their solution consists of only one or two steps. The principal error made is usually a misplaced decimal point. The most common type percentage problem is finding:

1. WHAT PERCENT ONE NUMBER IS OF ANOTHER

   In this case, the problem is simply one of reading carefully to determine the correct fraction and then converting to a percentage.

Example: What percent is 20 of 25?

$$\frac{20}{25} = \frac{4}{5} = 0.8$$

$$0.8 \times 100\% = 80\%$$

Example: Four is what percent of 14?

$$\frac{4}{14} = 0.2857$$

$$0.2857 \times 100\% = 28.57\%$$

Example: The input or brake horsepower to a pump is 20 horsepower. Output or water horsepower is 15 hp. What is the efficiency of the pump?

$$\begin{aligned}\text{Efficiency, \%} &= \frac{\text{Output}}{\text{Input}} \times 100\% \\ &= \frac{\text{Water hp}}{\text{Brake hp}} \times 100\% \\ &= \frac{15\text{ hp}}{20\text{ hp}} \times 100\% \\ &= 75\%\end{aligned}$$

Another type of percentage problem is finding:

2. PERCENT OF A GIVEN NUMBER

In this case the percent is expressed as a decimal, and the two numbers are multiplied together.

Example: Find 7% of 32.

$$0.07 \times 32 = 2.24$$

Example: Find 90% of 5.

$$.90 \times 5 = 4.5$$

Example: What is the weight of dry soil in a sample weighing 328 grams if the sample contains 5% water and 95% soil?

$$\text{Soil, \%} = \frac{\text{Dry Soil, gm}}{\text{Total Weight, gm}} \times 100\%$$

$$\text{Dry Soil, gm} = \frac{\text{Total Weight, gm} \times \text{Soil, \%}}{100\%}$$

$$= \frac{328 \text{ gm} \times 95\%}{100\%}$$

$$= 311.6 \text{ gm}$$

A variation of the preceding problem is:

3. FINDING A NUMBER WHEN A GIVEN PERCENT OF IT IS KNOWN

Since this problem is similar to the previous problem, the solution is to convert to a decimal and divide by the decimal.

Example: If 5% of a number is 52, what is the number?

$$\frac{52}{0.05} = 1040$$

A check calculation may now be performed -- what is 5% of 1040?

$0.05 \times 1040 = 52$ (Check)

Example: 16 is 80% of what amount?

$$\frac{16}{0.80} = 20$$

Example: An electric motor for a pump is 90% efficient. If the motor must deliver 720 watts, how many watts are required to run the motor?

$$\text{Efficiency, \%} = \frac{\text{Output}}{\text{Input}} \times 100\%$$

$$90\% = \frac{720 \text{ watts}}{\text{Input, watts}} \times 100\%$$

$$\text{Input, watts} = \frac{720 \text{ watts} \times 100\%}{90\%}$$

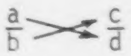
$$= 800 \text{ watts}$$

M.39 Ratio and Proportion

Ratio is the comparison of two numbers of the same denomination. For example, 1 inch compared to 3 inches, or 3 boxes compared to 7 boxes. Ratios are written either as fractions, 1/3, or as 1:3 (which is read "the ratio of one to three").

Proportion is the equating of ratios. For example, 3/6 is equal to 1/2. A proportion is usually written in the form a/b = c/d, or a:b = c:d (which is read as *a* is to *b* as *c* is to *d*).

To solve the proportion a/b = c/d, we multiply diagonally across



Therefore, a x d = b x c. This procedure is sometimes called cross multiplication.

This can be proved by substituting the previous example:

$$\frac{3}{6} = \frac{1}{2}$$

$$3 \times 2 = 6 \times 1$$

$$6 = 6$$

When one complete ratio is known and one term of the second ratio is known, the proportion relationship indicates what the unknown number should be.

For instance, if one number from the previous example were missing, the number could be found by cross multiplying.

$$\frac{a}{6} = \frac{1}{2}$$

$$a \times 2 = 6 \times 1$$

$$\frac{a \times 2}{2} = \frac{6 \times 1}{2} \qquad \text{Divide both sides of equation by 2.}$$

$$a = \frac{6 \times 1}{2}$$

$$= \frac{6}{2}$$

$$= 3$$

A few example problems should indicate how to deal with ratios and proportions.

Example: Certain bolts cost 90 cents a dozen. How much would three bolts cost?

In setting up this proportion, we would say: 12 bolts cost 90 cents; 3 bolts cost x cents. Therefore, the proportion is written either as $12/3 = 90/x$ or $12/90 = 3/x$.

$$\frac{12}{90} = \frac{3}{x}$$

$$12 \times x = 90 \times 3$$

$$x = \frac{90 \times 3}{12}$$

$$= \frac{90}{4}$$

$$= 22\ 1/2 \text{ or } 23¢ \text{ (to the nearest penny)}$$

Example: If 3 lbs of salt are added to 10 gallons of water to make a solution of a given strength, how many pounds would be added to 129 gallons to make a solution of the same concentration?

$$\frac{3\text{ lbs}}{10\text{ gal}} = \frac{x}{129\text{ gal}}$$

$$x\,(10\text{ gal}) = 3\text{ lbs}\,(129\text{ gal})$$

$$x = \frac{3\text{ lbs}\,(129\ \cancel{\text{gal}})}{10\ \cancel{\text{gal}}}$$

$$= \frac{387\text{ lbs}}{10}$$

$$= 38.7\text{ lbs}$$

NOTE: Gallons in the numerator and gallons in the denominator can be canceled without changing the value of the solution.

Although proportions are usually not difficult to solve, some care must be taken when using them. Some varying quantities are inversely proportional to each other. Their products, rather than their ratios, are constant. This can be easily explained by an example.

Example: If three men can do a certain job in 10 hours, how long would it take five men to do the same job?

This problem is inversely proportional. If this fact were not noticed, many would solve it by direct proportion.

$$\frac{3\text{ men}}{10\text{ hours}} = \frac{5\text{ men}}{x\text{ hrs}}$$

$$x = \frac{5\ \cancel{\text{men}} \times 10\text{ hrs}}{3\ \cancel{\text{men}}}$$

$$= \frac{50\text{ hrs}}{3}$$

$$= 16\ 2/3\text{ hrs} \quad \text{(Wrong)}$$

The solution is wrong since increasing the manpower should decrease the time required to do the job. The problem is therefore inversely proportional and the products of the varying quantities should be equated.

$$3 \text{ men} \times 10 \text{ hours} = 5 \text{ men } (x \text{ hrs})$$

$$x = \frac{3 \cancel{\text{men}} \times 10 \text{ hrs}}{5 \cancel{\text{men}}}$$

$$= 6 \text{ hrs}$$

It is important for the worker to remember that gas pressure-volume problems are also inversely proportional. The higher the pressure, the smaller the volume of gas.

Example: A vessel contains 100 cubic feet of gas at 5 lbs per square inch pressure. What is the pressure if the volume is reduced to 40 cubic feet?

$$100 \text{ cu ft} \times 5 \text{ psi} = 40 \text{ cu ft } (x \text{ psi})$$

$$x = \frac{100 \cancel{\text{cu}}\ \cancel{\text{ft}} \times 5 \text{ psi}}{40 \cancel{\text{cu}}\ \cancel{\text{ft}}}$$

$$= \frac{500 \text{ psi}}{40}$$

$$= 12.5 \text{ psi}$$

NOTE: In this problem the temperature was assumed to remain constant. Gas pressures are given in psi absolute values (see Section M.80, Pressure).

M.4 SQUARES, CUBES, AND ROOTS

M.40 Squares and Square Roots

Squaring a number simply means multiplying a number by itself. For instance, in squaring two we obtain four (2 x 2 = 4). In squaring three, the answer is nine. A short way of writing 2 x 2 is by using the superscript 2 in the following manner, 2^2. Thus, if we were trying to indicate the squaring of numbers we would write:

$1^2 = 1$

$2^2 = 4$

$3^2 = 9$

$4^2 = 16$

$5^2 = 25$, and so on

A reverse of this process is to take a number that has been squared and find the number which was multiplied by itself to form the square. This process is called finding the square root. The sign $\sqrt{}$ indicates square root. The square root of 4 is written, $\sqrt{4}$, and the answer is 2. The reverse of the previous column would then be:

$(1)^{\frac{1}{2}} = \sqrt{1} = 1$

$(4)^{\frac{1}{2}} = \sqrt{4} = 2$

$(9)^{\frac{1}{2}} = \sqrt{9} = 3$

$(16)^{\frac{1}{2}} = \sqrt{16} = 4$

$(25)^{\frac{1}{2}} = \sqrt{25} = 5$, and so on

A difficulty arises when the square root of a number does not result in a whole number. Such is the case for $\sqrt{20}$. Since the $\sqrt{16}$ is 4, and the $\sqrt{25}$ is 5, the answer is between 4 and 5. The best way to find the $\sqrt{20}$ is to use a calculator, slide rule or table of square roots.

M.41 Cubes and Cube Roots

Multiplying a number by itself twice results in the cube of the number. For example, the cube of 2 is $2 \times 2 \times 2 = 2^3$, or 8. The cube of a number is indicated by a superscript 3.

$$1^3 = 1$$

$$2^3 = 8$$

$$3^3 = 27$$

$$4^3 = 64$$

$$5^3 = 125, \text{ and so on}$$

The reverse of this process is to take the cube root of a number.

The sign $\sqrt[3]{\quad}$ indicates cube root.

$$\begin{aligned}
(125)^{1/3} &= \sqrt[3]{125} = 5 \\
(64)^{1/3} &= \sqrt[3]{64} = 4 \\
(27)^{1/3} &= \sqrt[3]{27} = 3 \\
(8)^{1/3} &= \sqrt[3]{8} = 2 \\
(1)^{1/3} &= \sqrt[3]{1} = 1
\end{aligned}$$

Cube roots can be found by methods similar to those discussed for square roots. The collection system worker usually does not come in contact with many problems involving cubes or cube roots.

M.5 AREAS

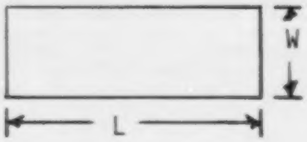
M.50 Dimensions

Areas are measured in two dimensions or in square units. In the English system of measurement the most common units are square inches, square feet, square yards, and square miles. In the metric system the units are square millimeters, square centimeters, square meters, and square kilometers.

M.51 Rectangle

The area of a rectangle is equal to its length (L) multiplied by its width (W).

$$A = L \times W$$



Example: Find the area of a rectangle if the length is 5 feet and the width is 3.5 feet.

$$\begin{aligned} \text{Area, sq ft} &= \text{Length, ft} \times \text{Width, ft} \\ &= 5\ \text{ft} \times 3.5\ \text{ft} \\ &= 17.5\ \text{ft}^2 \\ &= 17.5\ \text{sq ft} \end{aligned}$$

Example: The surface area of a loading dock is 330 square feet. One side measures 15 feet. How long is the other side?

$$A = L \times W$$

$$330\ \text{sq ft} = L\ \text{ft} \times 15\ \text{ft}$$

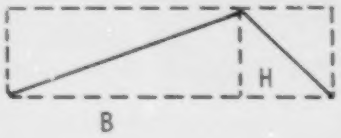
$$\frac{L\ \text{ft} \times 15\ \text{ft}}{15\ \text{ft}} = \frac{330\ \text{ft}^2}{15\ \text{ft}}$$ Divide both sides of equation by 15 ft.

$$\begin{aligned} L\ \text{ft} &= \frac{330\ \text{ft}^2}{15\ \text{ft}} \\ &= 22\ \text{ft} \end{aligned}$$

M.52 Triangle

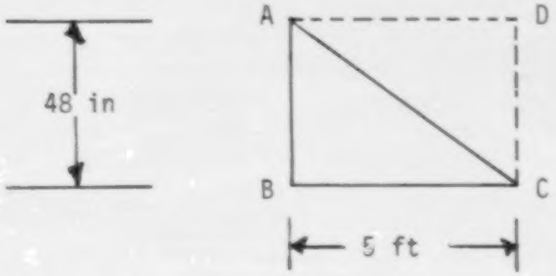
The area of a triangle is equal to one half the base multiplied by the height. This is true for any triangle.

$$\boxed{A = \frac{1}{2} B \times H}$$



NOTE: The area of any triangle is equal to 1/2 the area of the rectangle that can be drawn around it. The area of the rectangle is B x H. The area of the triangle is 1/2 B x H.

Example: Find the area of triangle ABC:



The first step in the solution is to make all the units the same. In this case, it is easier to change inches to feet.

$$48 \text{ in} = 48 \cancel{\text{in}} \times \frac{1 \text{ ft}}{12 \cancel{\text{in}}} = \frac{48}{12} \text{ ft} = 4 \text{ ft}$$

NOTE: All conversions should be calculated in the above manner. Since 1 ft/12 in is equal to unity, or one, multiplying by this factor changes the form of the answer but not its value.

Area, sq ft = 1/2 (Base, ft)(Height, ft)

= 1/2 x 5 ft x 4 ft

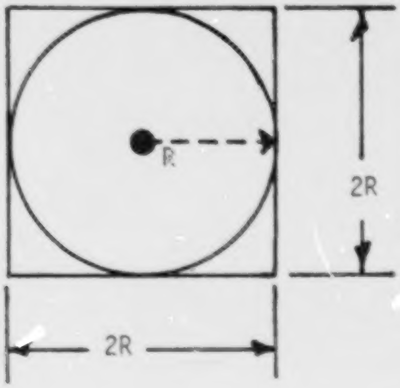
= $\frac{20}{2}$ ft^2

= 10 sq ft

NOTE: Triangle ABC is one half the area of rectangle ABCD. The triangle is a special form called a Right Triangle since it contains a 90° angle at point B.

M.53 Circle

A square with sides of 2R can be drawn around a circle with a radius* of R.



The area of the square is: $A = 2R \times 2R = 4R^2$.

It has been found that the area of any circle inscribed within a square is slightly more than 3/4 of the area of the square. More precisely, the area of the preceding circle is:

$$A\ \text{circle} = 3\frac{1}{7}R^2 = 3.14\ R^2$$

The formula for the area of a circle is usually written:

$$\boxed{A = \pi R^2}$$

---

*Radius. The distance from the center to the outside of a circle.

The Greek letter π (pronounced pie) merely substitutes for the value 3.1416.

Since the diameter of any circle is equal to twice the radius, the formula for the area of a circle can be rewritten as follows:

$$A = \pi R^2 = \pi \times R \times R = \pi \times \frac{D}{2} \times \frac{D}{2} = \frac{\pi D^2}{4} = \frac{3.14}{4} D^2 = \boxed{0.785\ D^2}$$

The type of problem and the magnitude of the numbers in a problem will determine which of the two formulas will provide a simpler solution. All of these formulas will give the same results if you use the same number of digits to the right of the decimal point.

Example: What is the area of a circle with a diameter of 20 centimeters?

In this case, the formula using a radius is more convenient since it takes advantage of multiplying by 10.

$$\begin{aligned} \text{Area, sq cm} &= \pi\ (\text{R, cm})^2 \\ &= 3.14 \times 10 \text{ cm} \times 10 \text{ cm} \\ &= 314 \text{ sq cm} \end{aligned}$$

Example: What is the area of a gasoline storage tank with a 5-foot radius?

In this case, the formula using diameter is more convenient.

$$\begin{aligned} \text{Area, sq ft} &= 0.785\ (\text{Diameter, ft})^2 \\ &= 0.785 \times 10 \text{ ft} \times 10 \text{ ft} \\ &= 78.5 \text{ sq ft} \end{aligned}$$

Occasionally the worker may be confronted with a problem giving the area and requesting the radius or diameter. This presents the special problem of finding the square root of the number.

Example: The surface area of a garden inside a traffic circle is approximately 5000 square feet. What is the diameter?

$A = 0.785\ D^2$, or

Area, sq ft = 0.785 (Diameter, ft)^2

5000 sq ft = $0.785\ D^2$ -- To solve, substitute given values in equation.

$$\frac{0.785\ D^2}{0.785} = \frac{5000 \text{ sq ft}}{0.785}$$ -- Divide both sides by 0.785 to find D^2.

$$D^2 = \frac{5000 \text{ sq ft}}{0.785}$$

= 6369 sq ft. Therefore,

D = square root of 6369 sq ft, or

Diameter, ft = $\sqrt{6369 \text{ sq ft}}$

To find the square root of 6369, try an electronic calculator, tables or a trial and error method. To illustrate the trial and error method, since 80 x 80 = 6400, we know the answer is close to 80 feet.

Try 79 x 79 = 6241

Try 79.5 x 79.5 = 6320.25

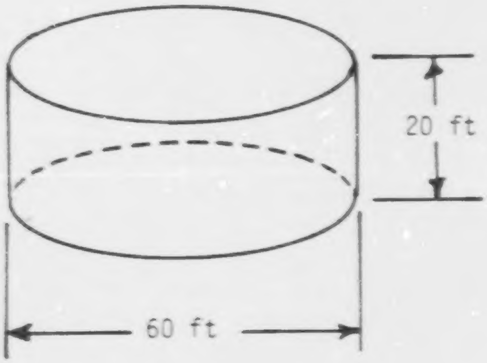
Try 79.8 x 79.8 = 6368.04 or almost 6369.

The diameter is 79.8 ft, or approximately 80 feet.

M.54 Cylinder

With the formulas presented thus far, it would be a simple matter to find the number of square feet in a room that was to be painted. The length of each wall would be added together and then multiplied by the height of the wall. This would give the surface area of the walls (minus any area for doors and windows). The ceiling area would be found by multiplying length times width and the result added to the wall area gives the total area.

The surface area of a circular cylinder, however, has not been discussed. If we wanted to know how many square feet of surface area are in a tank with a diameter of 60 feet and a height of 20 feet, we could start with the top and bottom.



The area of the top and bottom ends are both $\pi \times R^2$.

$$\text{Area, sq ft} = 2 \text{ ends } (\pi)(\text{Radius, ft})^2$$

$$= 2 \times \pi \times (30 \text{ ft})^2$$

$$= 5652 \text{ sq ft}$$

The surface area of the wall must now be calculated. If we made a vertical cut in the wall and unrolled it; the straightened wall would be the same length as the circumference of the floor and ceiling.

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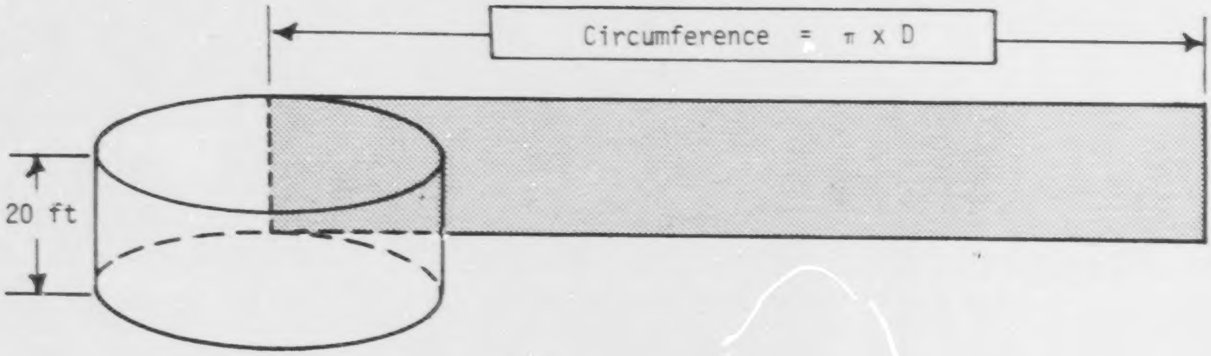

This length has been found to always be π x D. In the case of the tank, the length of the wall would be:

Length, ft = (π) (Diameter, ft)
= 3.14 x 60 ft
= 188.4 ft

Area would be:

A_W, sq ft = Length, ft x Height, ft
= 188.4 ft x 20 ft
= 3768 sq ft

Outside Surface Area to Paint, sq ft = Area of top and bottom, sq ft + Area of wall, sq ft
= 5652 sq ft + 3768 sq ft
= 9420 sq ft

A container has inside and outside surfaces and you may need to paint both of them.

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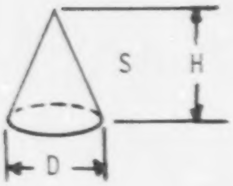
M.55 Cone



The lateral area of a cone is equal to 1/2 of the slant height (S) multiplied by the circumference of the base.

$$\boxed{A_L = 1/2\ S \times \pi \times D = \pi \times S \times R}$$

In the case the slant height is not given, it may be calculated by:

$$S = \sqrt{R^2 + H^2}$$

Example: Find the entire outside area of a cone with a diameter of 30 inches and a height of 20 inches.

$$\text{Slant Height, in} = \sqrt{(\text{Radius, in})^2 + (\text{Height, in})^2}$$

$$= \sqrt{(15\text{ in})^2 + (20\text{ in})^2}$$

$$= \sqrt{225\text{ in}^2 + 400\text{ in}^2}$$

$$= \sqrt{625\text{ in}^2}$$

$$= 25\text{ in}$$

$$\text{Area of Cone, sq in} = \pi\,(\text{Slant Height, in})(\text{Radius, in})$$

$$= 3.14 \times 25\text{ in} \times 15\text{ in}$$

$$= 1177.5\text{ sq in}$$

Since the entire area was asked for, the area of the base must be added.

Area, sq in = 0.785 (Diameter, in)^2

= 0.785 x 30 in x 30 in

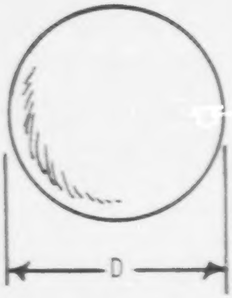
= 706.5 sq in

Total Area, sq in = Area of Cone, sq in + Area of Bottom, sq in

= 1177.5 sq in + 706.5 sq in

= 1884 sq in

M.56 Sphere



The surface area of a sphere or ball is equal to π multiplied by the diameter squared.

$$\boxed{A_S = \pi D^2}$$

If the radius is used, the formula becomes:

$$A_S = \pi D^2 = \pi \times 2R \times 2R = 4\pi R^2$$

Example: What is the surface area of a sphere shaped methane gas container 20 feet in diameter?

Area, sq ft = π (Diameter, ft)^2

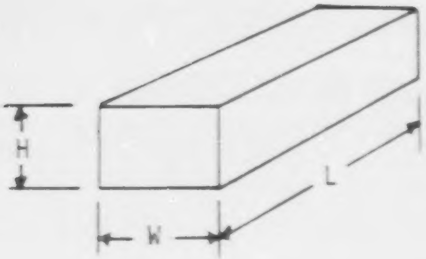
= 3.14 x 20 ft x 20 ft

= 1256 sq ft

M.6 VOLUMES

M.60 Rectangle

Volumes are measured in three dimensions or in cubic units. To calculate the volume of a rectangle, the area of the base is calculated in square units and then multiplied by the height. The formula then becomes:



$$\boxed{V = L \times W \times H}$$

Example: The length of a box is two feet, the width is 15 inches, and the height is 18 inches. Find its volume.

$$\text{Volume, cu ft} = \text{Length, ft} \times \text{Width, ft} \times \text{Height, ft}$$

$$= 2 \text{ ft} \times 1\tfrac{1}{4} \text{ ft} \times 1\tfrac{1}{2} \text{ ft}$$

$$= 2 \text{ ft} \times \frac{5}{4} \text{ ft} \times \frac{3}{2} \text{ ft}$$

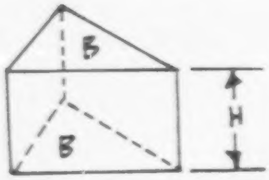
$$= \frac{15}{4} \text{ cu ft}$$

$$= 3\tfrac{3}{4} \text{ cu ft}$$

M.61 Prism

The same general rule that applies to a rectangle also applies to a prism.

$$\boxed{\text{Volume} = \text{Area of Base} \times \text{Height}}$$



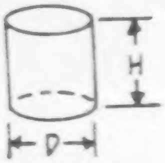
Example: Find the volume of a prism with a base area of 10 square feet and a height of 5 feet.

$$\begin{aligned}\text{Volume, cu ft} &= \text{Area of Base, sq ft} \times \text{Height, ft}\\ &= 10 \text{ sq ft} \times 5 \text{ ft}\\ &= 50 \text{ cu ft}\end{aligned}$$

M.62 Cylinder

The volume of a cylinder is equal to the area of the base multiplied by the height.

$$\boxed{V = \pi R^2 \times H = 0.785\, D^2 \times H}$$



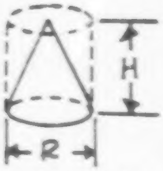
Example: A 24-inch sewer is 360 feet long. Find the volume. Use length instead of height.

$$\begin{aligned}\text{Volume, cu ft} &= 0.785 \times (\text{Diameter, ft})^2 \times \text{Length, ft}\\ &= 0.785 \times 2 \text{ ft} \times 2 \text{ ft} \times 360 \text{ ft}\\ &= 1131 \text{ cu ft}\end{aligned}$$

M.63 Cone

The volume of a cone is equal to 1/3 the volume of circular cylinder of the same height and diameter.

$$\boxed{V = \frac{\pi}{3} R^2 \times H}$$



Example: Calculate the volume in a cone if the depth is 4 ft. and the radius is 50 ft.

$$\text{Volume, cu ft} = \frac{\pi}{3} \times (\text{Radius})^2 \times \text{Height, ft}$$

$$= \frac{\pi}{3} \times 50 \text{ ft} \times 50 \text{ ft} \times 4 \text{ ft}$$

$$= 10{,}472 \text{ cu ft}$$

M.64 Sphere

The volume of a sphere is equal to $\pi/6$ times the diameter cubed.

$$\boxed{V = \frac{\pi}{6} \times D^3}$$

Example: How much gas can be stored in a sphere with a diameter of 12 feet? (Assume atmospheric pressure.)

$$\text{Volume, cu ft} = \frac{\pi}{6} \times (\text{Diameter, ft})^3$$

$$= \frac{\pi}{\cancel{6}} \times \overset{2}{\cancel{12}} \text{ ft} \times 12 \text{ ft} \times 12 \text{ ft}$$

$$= 905 \text{ cubic feet}$$

M.7 STEPS IN SOLVING PROBLEMS

M.70 Identify Problem

To solve any problem, you have to identify the problem, determine what kind of answer is needed, and collect the information needed to solve the problem. A good approach to this type of problem is to examine the problem and make a list of known and unknown information.

Example: Find the time to fill a large rectangular storm water storage basin 8 feet deep, 30 feet wide, and 60 feet long when the flow is 1.4 MGD.

Known	Unknown
Depth = 8 ft	Fill Time, hours
Width = 30 ft	
Length = 60 ft	
Flow = 1.4 MGD	

Sometimes a drawing or sketch will help to illustrate a problem and indicate the knowns, unknowns, and possibly additional information needed.

M.71 Selection of Formula

Most problems involving mathematics of wastewater collection systems can be solved by selecting the proper formula, inserting the known information, and calculating the unknown. To solve this problem, the formula from Section M.119 is

$$\text{Fill Time, hrs} = \frac{(\text{Tank Volume, cu ft})(7.5\text{ gal/cu ft})(24\text{ hr/day})}{\text{Flow, gal/day}}$$

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To convert the known information to fit the terms in a formula sometimes requires extra calculations. The next step is to find the values of any terms in the formula that are not in the list of known values.

Flow, gal/day = 1.4 MGD

= 1,400,000 gal/day

From Section M.112:

Tank Volume, cu ft = (Length, ft)(Width, ft)(Height, ft)

= 60 ft x 30 ft x 8 ft

= 14,400 cu ft

Solution of Problem:

$$\text{Fill Time, hrs} = \frac{(\text{Tank Volume, cu ft})(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}{\text{Flow, gal/day}}$$

$$= \frac{(14{,}400\ \text{cu ft})(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}{1{,}400{,}000\ \text{gal/day}}$$

$$= 1.9\ \text{hr}$$

The remainder of this section discusses the details that must be considered in solving this problem.

M.72 Units and Dimensional Analysis

Each term in a formula or mathematical calculation must be of the correct units. The area of a rectangular storage basin (Area, sq ft = Length, ft x Width, ft) can't be calculated in square feet if the width is given as 246 inches or 20 feet 6 inches. The width must

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be converted to 20.5 feet. In the example problem, if the tank volume were given in gallons, then the 7.5 gal/cu ft would not be needed. The units in a formula must always be checked before any calculations are performed to avoid time-consuming mistakes.

$$\text{Fill Time, hrs} = \frac{(\text{Tank Volume, cu ft})(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}{\text{Flow, gal/day}}$$

$$= \underline{\cancel{\text{cu ft}}} \times \frac{\cancel{\text{gal}}}{\cancel{\text{cu ft}}} \times \frac{\text{hr}}{\cancel{\text{day}}} \times \frac{\cancel{\text{day}}}{\cancel{\text{gal}}}$$

$$= \text{hr} \quad \text{(all other units cancel)}$$

NOTE: We have hours = hr. One should note that the hour unit on both sides of the equation can be cancelled out, and nothing would remain. This is one more check that we have the correct units. By rearranging the fill time formula, other unknowns could be determined.

If the design fill time and design flow were known, the required capacity of the tank could be calculated.

$$\text{Tank Volume, cu ft} = \frac{(\text{Fill Time, hr})(\text{Flow, gal/day})}{(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}$$

If the tank volume and design fill time were known, the design flow could be calculated.

$$\text{Flow, gal/day} = \frac{(\text{Tank Volume, cu ft})(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}{\text{Fill Time, hr}}$$

Rearrangement of the fill time formula to find other unknowns illustrates the need to always use the correct units.

M.73 Calculations

Sections M.22, Multiplication, and M.23, Division, outline the steps to follow in mathematical calculations. In general, do the calculations inside parentheses ( ) first and brackets [ ] next. Calculations should be done above and below the division line before dividing.

$$\text{Fill Time, Hrs} = \frac{(\text{Tank Volume, cu ft})(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}{\text{Flow, gal day}}$$

$$= \frac{(14{,}400\ \text{cu ft})(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}{1{,}400{,}000\ \text{gal/day}}$$

$$\begin{array}{r} 24 \\ \underline{7.5} \\ 120 \\ \underline{168} \\ 180.0 \end{array} \qquad \begin{array}{r} 14400 \\ \underline{180} \\ 1152000 \\ \underline{14400} \\ 2{,}592{,}000 \end{array}$$

$$= \frac{2{,}592{,}\cancel{000}\ \text{gal-hr/day}}{1{,}400{,}\cancel{000}\ \text{gal/day}}$$

$$\begin{array}{r} 1.85 \\ 1400\overline{)\,2592} \\ \underline{1400} \\ 11920 \\ \underline{11200} \\ 7200 \\ 7000 \end{array}$$

$= 1.85$, or

$= 1.9$ hr

M.74 Significant Figures

In calculating the fill time in the previous section the answer is given as 1.9 hr. The answer could have been calculated:

$$\text{Fill Time, hrs} = \frac{2{,}592{,}000\ \text{gal-hr/day}}{1{,}400{,}000\ \text{gal/day}}$$

$= 1.851428571428571423$....hours

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How does one know when to stop dividing? Common sense and significant figures both help.

First, consider the meaning of fill time and the measurements that were taken to determine the knowns in the formula. Fill time in a tank is a theoretical value.

Will the flow of 1.4 MGD be constant throughout the 1.9 hours, and is the flow exactly 1.4 MGD, or could it be 1.35 MGD or 1.428 MGD? A carefully calibrated flow meter may give a reading within 2% of the actual flow rate. Flows into a tank fluctuate and flow meters do not measure flows extremely accurately; so the fill time again appears to be a representative or typical fill time.

Tank dimensions are probably satisfactory within 0.1 ft. A flow meter reading of 1.4 MGD is less precise and it could be 1.3 or 1.5 MGD. A 0.1 MGD flow meter error when the flow is 1.4 MGD is (0.1/1.4) x 100% = 7% error. A fill time of 1.9 hours, based on a flow meter reading error of plus or minus 7%, also could have the same error or more, even if the flow was constant. Therefore, the fill time error could be 1.9 hours x 0.07 = ±0.13 hours.

In most of the calculations in the operation and maintenance of wastewater collection systems, the worker uses measurements determined in the field or read from charts, scales, or meters. The accuracy of every measurement depends on the sample being measured, the equipment doing the measuring, and the worker reading or measuring the results. Your estimate is no better than the least precise measurement. Do not retain more than one doubtful number.

To determine how many figures or numbers mean anything in an answer, the approach called "significant figures" is used. In the example the flow was given in two significant figures (1.4 MGD), and the tank dimensions could be considered accurate to the nearest tenth of a foot (depth = 9.0 ft) or two significant figures. Since all measurements and the constants contained two significant figures, the results should be reported as two significant figures or 1.9 hours. The calculations are normally carried out to three significant figures (1.85 hours) and rounded off to two significant figures (1.9 hours).

Decimal points require special attention when determining the number of significant figures in a measurement.

Measurement	Significant Figures
0.00325	3
11.078	5
21,000.	2

Example: The distance between two points was divided into three sections, and each section was measured by a different group. What is the distance between the two points if each group reported the distance it measured as follows:

Group	Distance, ft	Significant Figures
A	11,300.	3
B	2,438.9	5
C	87.62	4
Total Distance	13,826.52	

Group A reported the length of the section it measured to three significant figures; therefore, the distance between the two points should be reported as 13,800 feet (3 significant figures).

When adding, subtracting, multiplying, or dividing, the number of significant figures in the answer should not be more than the term in the calculations with the least number of significant figures.

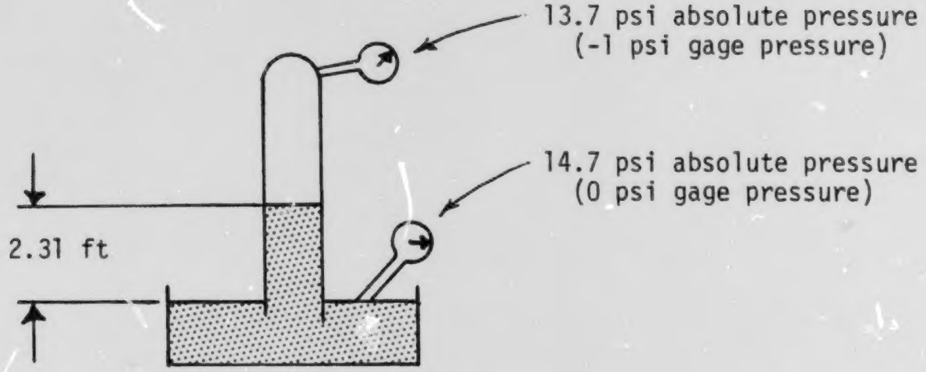
M.75 Check Your Results

After having completed your calculations, you should carefully examine your calculations and answer. Does the answer seem reasonable? If possible, have another worker check your calculations before making any decisions or recommendations.

M.8 PUMPS

M.80 Pressure

Atmospheric pressure at sea level is approximately 14.7 psi. This pressure acts in all directions and on all objects. If a tube is placed upside down in a basin of water and a 1 psi partial vacuum is drawn on the tube, the water in the tube will rise 2.31 feet.


13.7 psi absolute pressure
(-1 psi gage pressure)
14.7 psi absolute pressure
(0 psi gage pressure)
2.31 ft

NOTE: 1 ft of water = 0.433 psi; therefore,

$$1 \text{ psi} = \frac{1}{0.433} \text{ ft} = 2.31 \text{ ft of water}$$

The action of the partial vacuum is what gets water out of a sump or well and up to a pump. It is not sucked up, but it is pushed up by atmospheric pressure on the water surface in the sump. If a complete vacuum could be drawn, the water would rise 2.31 x 14.7 = 33.9 feet; but this is impossible to achieve. The practical limit of the suction lift of a positive displacement pump is about 22 feet, and that of a centrifugal pump is 15 feet.

M.81 Work

Work can be expressed as lifting a weight a certain vertical distance. It is usually defined in terms of foot-pounds.

Example: A 165-pound man runs up a flight of stairs 20 feet high. How much work did he do?

$$\begin{aligned} \text{Work, ft-lb} &= \text{Weight, lb} \times \text{Height, ft} \\ &= 165 \text{ lb} \times 20 \text{ ft} \\ &= 3300 \text{ ft-lb} \end{aligned}$$

M.82 Power

Power is a rate of doing work and is usually expressed in foot-pounds per minute.

Example: If the man in the above example runs up the stairs in three seconds, how much power has he exerted?

$$\text{Power, ft-lbs/min} = \frac{\text{Work, ft-lb}}{\text{Time, sec}} \times \frac{60 \text{ sec}}{\text{minute}}$$

$$= \frac{3300 \text{ ft-lbs}}{3 \cancel{\text{sec}}} \times \frac{60 \cancel{\text{sec}}}{\text{minute}}$$

$$= 66{,}000 \text{ ft-lb/min}$$

M.83 Horsepower

Horsepower is also a unit of power. One horsepower is defined as 33,000 ft-lbs per minute or 746 watts.

Example: How much horsepower has the man in the previous example exerted as he climbs the stairs?

$$\text{Horsepower, HP} = (\text{Power, ft-lb/min}) \left(\frac{\text{HP}}{33{,}000 \text{ ft-lb/min}}\right)$$

$$= 66{,}000 \text{ ft-lb/min} \times \frac{\text{Horsepower}}{33{,}000 \text{ ft-lb/min}}$$

$$= 2 \text{ HP}$$

Work is also done by lifting water. If the flow from a pump is converted to a weight of water and multiplied by the vertical distance it is lifted, the amount of work or power can be obtained.

$$\text{Horsepower, HP} = \frac{\text{Flow, gal}}{\text{min}} \times \text{Lift, ft} \times \frac{8.34\ \text{lb}}{\text{gal}} \times \frac{\text{Horsepower}}{33{,}000\ \text{ft-lb/min}}$$

Solving the above relation, the amount of horsepower necessary to lift the water is obtained. This is called water horsepower.

$$\text{Water, HP} = \frac{(\text{Flow, gpm})(\text{H, ft})}{3960^{*}}$$

However, since pumps are not 100% efficient (they cannot transmit all the power put into them), the horsepower supplied to a pump is greater than the water horsepower. Horsepower supplied to the pump is called brake horsepower.

$$\text{Brake, HP} = \frac{\text{Flow, gpm} \times \text{H, ft}}{3960 \times E_p}$$

E_p = Efficienty of Pump (Usual range 50-85%, depending on type and size of pump)

Motors are also not 100% efficient; therefore, the power supplied to the motor is greater than the motor transmits.

$$\text{Motor, HP} = \frac{\text{Flow, gpm} \times \text{H, ft}}{3960 \times E_p \times E_m}$$

E_m = Efficiency of motor (Usual range 80-95%, depending on type and size of motor)

The above formulas have been developed for the pumping of water and wastewater which have a specific gravity of 1.0. If other liquids are to be pumped, the formulas must be multiplied by the specific gravity of the liquid.

Example: A flow of 500 gpm of water is to be pumped against a total head of 100 feet by a pump with an efficiency of 70%. What is the pump horsepower?

$$\star\ \frac{8.34\ \text{lb}}{\text{gal}} \times \frac{\text{HP}}{33{,}000\ \text{ft-lb/min}} = \frac{1}{3960}$$

1 gallon weighs 8.34 pounds and 1 horsepower is the same as 33,000 ft-lb/min

H or Head in feet is the same as Lift in feet.

$$\text{Brake, HP} = \frac{\text{Flow, gpm} \times \text{H, ft}}{3960 \times E_p}$$

$$= \frac{500 \times 100}{3960 \times 0.70}$$

$$= 18 \text{ HP}$$

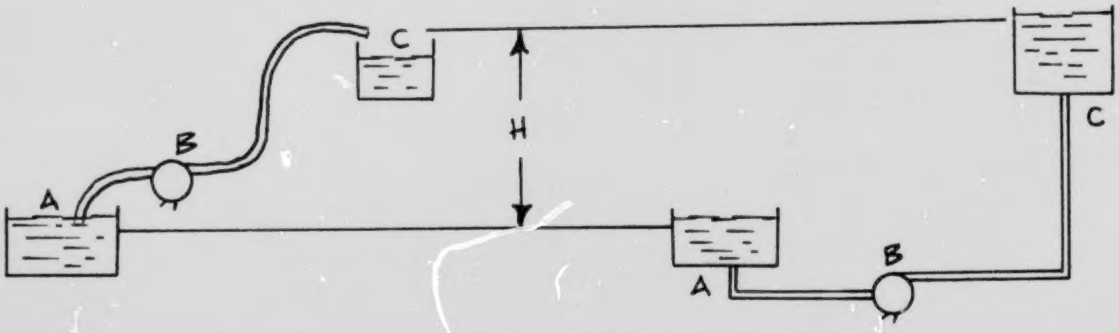
Example: Find the horsepower required to pump gasoline (specific gravity = 0.75) in the above problem.

$$\text{Brade, HP} = \frac{500 \times 100 \times 0.75}{3960 \times 0.70}$$

$$= 13.5 \text{ HP}$$ (Gasoline is lighter and requires less horsepower)

M.84 Head

Basically, the head that a pump must work against is determined by measuring the vertical distance between the two water surfaces, or the distance the water must be lifted. This is called the static head. Two typical conditions for lifting water are shown below:



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If a pump were designed in the above examples to pump only against head H, the water would never reach the intended point. The reason for this is that the water encounters friction in the pipelines. Friction depends on the roughness and length of pipe, the pipe diameter, and the flow velocity. The turbulence caused at the pipe entrance (point A); the pump (point B); the pipe exit (point C); and at each elbow, bend, or transition also adds to these friction losses. Tables and charts are available for calculation of these friction losses so they may be added to the measured or static head to obtain the total head. For short runs of pipe which do not have high velocities, the friction losses are generally less than 10% of the static head.

Example: A pump is to be located eight feet above a wet well and must lift 1.8 MGD another 50 feet to a storage reservoir. If the pump has an efficiency of 75% and the motor an efficiency of 90%, what is the cost of the power consumed if one kilowatt-hour costs 2 cents?

Since we are not given the length or size of pipe and the number of elbows or bends, we will assume friction to be 10% of static head.

Static Head, ft = Suction Lift, ft + Discharge Head, ft

= 8 ft + 50 ft

= 58 ft

Friction Losses, ft = 0.1 (Static Head, ft)

= 0.1 (58 ft)

= 5.8 ft

Total Dynamic Head, ft = Static Head, ft + Friction Losses, ft

= 58 ft + 5.8 ft

= 63.8 ft

Flow, gpm $= \frac{1{,}800{,}000 \text{ gal}}{\cancel{\text{day}}} \; \frac{\cancel{\text{day}}}{24 \cancel{\text{hr}}} \; \frac{1 \cancel{\text{hr}}}{60 \text{ min}}$

$=$ 1250 gpm (assuming pump runs 24 hours per day)

Motor, HP $= \frac{\text{Flow, gpm} \times \text{H, ft}}{3960 \times E_p \times E_m}$

$= \frac{1250 \times 63.8}{3960 \times 0.75 \times 0.9}$

$=$ 30 HP

Kilowatt-hrs $= 30 \cancel{\text{HP}} \times 24 \text{ hrs/day} \times 0.746 \text{ kw/}\cancel{\text{HP}}$

$=$ 537 kilowatt-hrs/day

Cost $=$ KWH x \$0.02/KWH

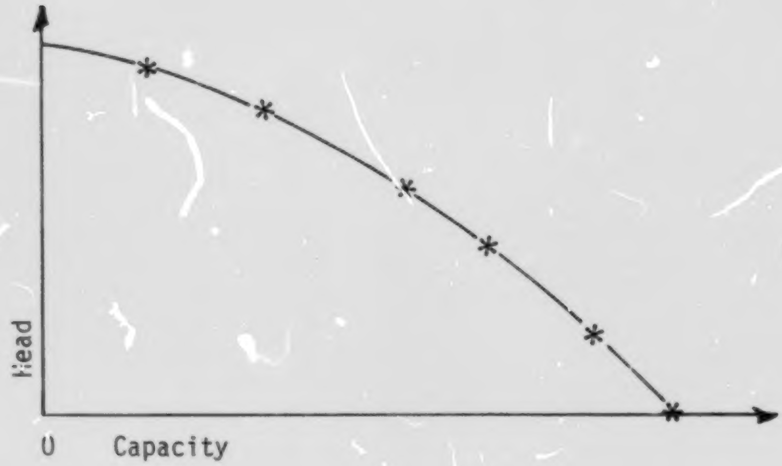
$=$ 537 x 0.02

$=$ \$10.74/day

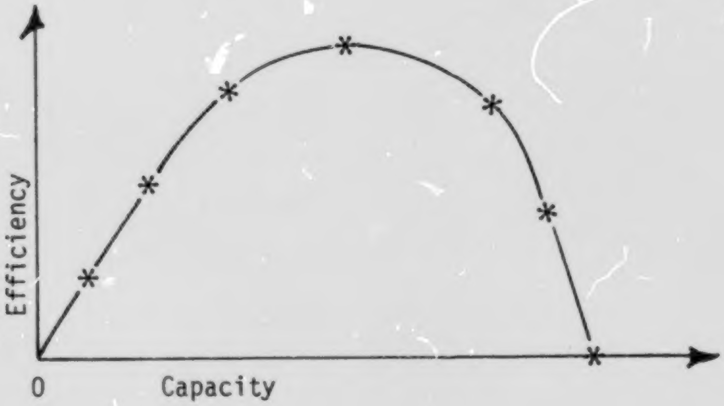
M.85 Pump Characteristics

The discharge of a centrifugal pump can be made to vary from zero to a maximum capacity which depends on the speed, head, power, and specific impeller design. The interrelations of capacity, efficiency, head, and power are known as the characteristics of the pump.

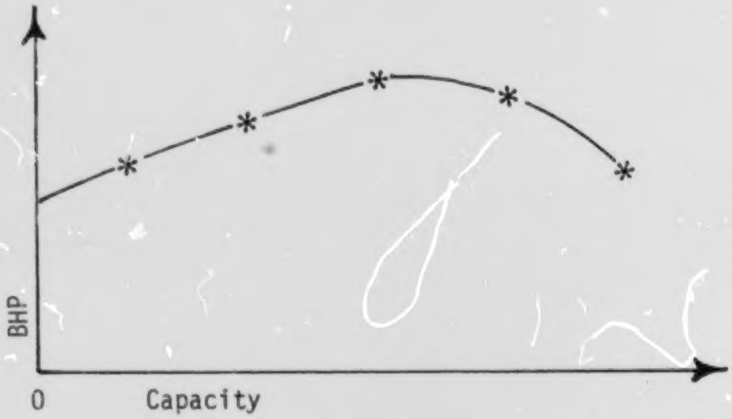
The first relation normally looked at when searching for a pump is the head vs. capacity. The head of a centrifugal pump usually rises as the capacity is reduced. If the values are plotted on a graph they appear as follows:



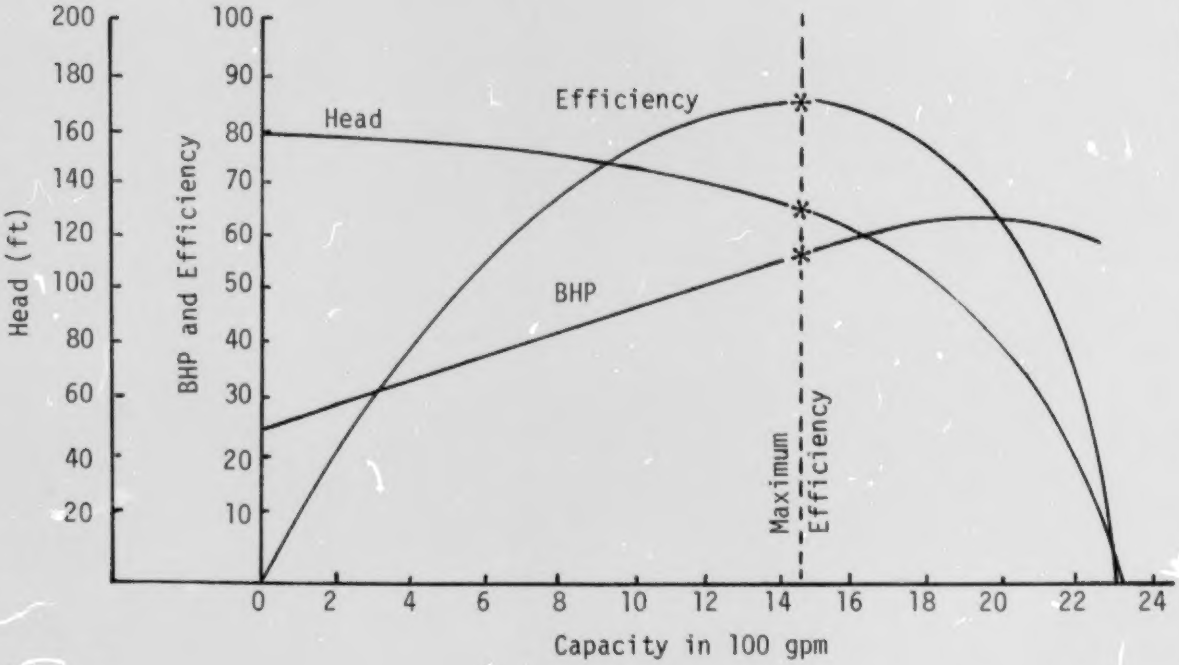
Another important characteristic is the pump efficiency. It begins from zero at no discharge, increases to a maximum, and then drops as the capacity is increased. Following is a graph of efficiency vs. capacity:



The last important characteristic is the brake horsepower or the power input to the pump. The brake horsepower usually increases with increasing capacity until it reaches a maximum, then it normally reduces slightly.



These pump characteristic curves are quite important. Pump sizes are normally picked from these curves rather than calculations. For ease of reading, the three characteristic curves are normally plotted together. A typical graph of pump characteristics is shown as follows:



The curves show that the maximum efficiency for the particular pump in question occurs at approximately 1475 gpm, a head of 132 feet, and a brake horsepower of 58. Operating at this point the pump has an efficiency of approximately 85%. This can be verified by calculation:

$$\text{BHP} = \frac{\text{Flow, gpm} \times \text{H, ft}}{3960 \times \text{E}}$$

As previously explained, a number can be written over one without changing its value:

$$\frac{\text{BHP}}{1} = \frac{\text{Flow} \times \text{H}}{3960 \times \text{E}}$$

Since the formula is now in ratio form, it can be cross multiplied.

$$\text{BHP} \times 3960 \times \text{E} = \text{Flow} \times \text{H} \times 1$$

Solving for E,

$$\text{E} = \frac{\text{Flow} \times \text{H}}{3960 \times \text{BHP}}$$

$$\text{E} = \frac{1475 \text{ gpm} \times 132 \text{ ft}}{3960 \times 58 \text{ HP}}$$

$$= 0.85 \text{ or } 85\% \quad \text{(Check)}$$

The preceding is only a brief description of pumps to familiarize the worker with their characteristics. The worker does not normally specify the type and size of pump needed at a lift station. If a pump is needed, the worker should be able to supply the information necessary for a pump supplier to provide the best possible pump for the lowest cost. Some of the information needed includes:

1. Flow range desired,
2. Head conditions,
    a. Suction head or lift
    b. Pipe and fitting friction head
    c. Discharge head
3. Type of fluid pumped and temperature,
4. Pump location.

M.86 Evaluation of Pump Performance

1. Capacity

Sometimes it is necessary to determine the capacity of a pump. This can be accomplished by determining the time it takes a pump to empty a portion of a wet well when all inflow is blocked off.

Example:

a. Measure the size of the wet well.

Length = 10 ft
Width = 10 ft
Depth = 8 ft
Distance = 5 ft

(We will measure the time it takes to lower the well a distance of of five feet.)

$$\text{Volume, cu ft} = \text{L, ft} \times \text{W, ft} \times \text{D, ft}$$

$$= 10 \text{ ft} \times 10 \text{ ft} \times 5 \text{ ft}$$

$$= 500 \text{ cu ft}$$

b. Record time for water to be lowered five feet in wet well.

Time = 10 minutes 30 seconds

= 10.5 minutes

c. Calculate pumping rate or capacity.

$$\text{Pumping Rate, gpm} = \frac{\text{Volume, gallons}}{\text{Time, minutes}}$$

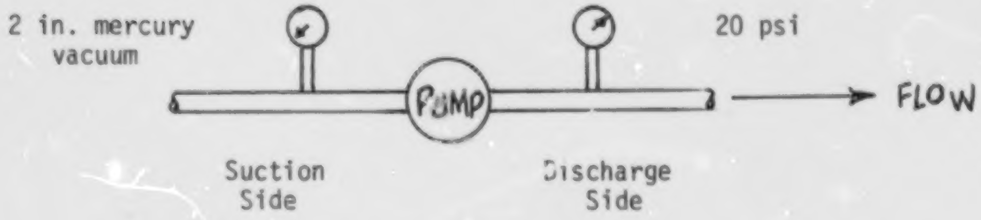
$$= \frac{(500 \text{ cu ft})(7.5 \text{ gal/cu ft})}{10.5 \text{ min}}$$

$$= \frac{3750}{10.5}$$

$$= 357 \text{ gpm}$$

2. Efficiency

To estimate the efficiency of the pump in the previous example, the total head must be known. This head may be estimated by measuring the suction and discharge pressures. Assume these were measured as follows:



No additional information is necessary if we assume the pressure gages are at the same height and the pipe diameters are the same. Both pressure readings must be converted to feet.

$$\text{Suction Head, ft} = 2 \text{ in Mercury} \times \frac{1.133 \text{ ft water*}}{1 \text{ in Mercury}}$$

$$= 2.27 \text{ ft}$$

$$\text{Discharge Head, ft} = 20 \text{ psi} \times 2.31 \text{ ft/psi*}$$

$$= 46.20 \text{ ft}$$

$$\text{Total Head, ft} = \text{Suction Head, ft} + \text{Discharge Head, ft}$$

$$= 2.27 \text{ ft} + 46.20 \text{ ft}$$

$$= 48.47 \text{ ft}$$

---

*See Conversion Tables at Back -- Section M.12 Pressure.

Calculate the power output of the pump or water horsepower:

$$\text{Water Horsepower, HP} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{3960}$$

$$= \frac{(357\ \text{gpm})(48.47\ \text{ft})}{3960}$$

$$= 4.4\ \text{HP}$$

To estimate the efficiency of the pump, measure the kilowatts drawn by the pump motor. Assume the meter indicates 8000 watts or 8 kilowatts. The manufacturer claims the electric motor is 80% efficient.

$$\text{Brake Horsepower, HP} = (\text{Power to elec. motor})(\text{motor eff.})$$

$$= \frac{(8\ \text{kw})(0.80)}{0.746\ \text{kw/HP}}$$

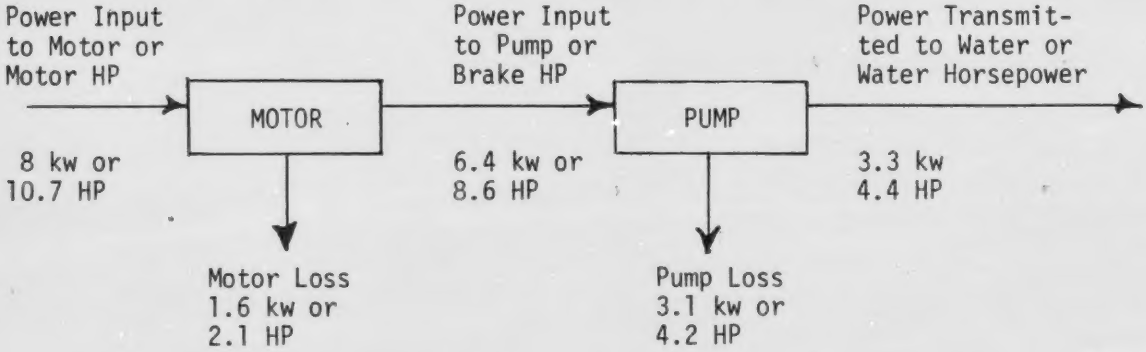
$$= 8.6\ \text{HP}$$

$$\text{Pump Efficiency, \%} = \frac{\text{Water Horsepower, HP} \times 100\%}{\text{Brake Horsepower, HP}}$$

$$= \frac{4.4\ \text{HP} \times 100\%}{8.6\ \text{HP}}$$

$$= 51\%$$

The following diagram may clarify the above problem:


Power Input to Motor or Motor HP
8 kw or 10.7 HP
MOTOR
Motor Loss 1.6 kw or 2.1 HP
Power Input to Pump or Brake HP
6.4 kw or 8.6 HP
PUMP
Pump Loss 3.1 kw or 4.2 HP
Power Transmitted to Water or Water Horsepower
3.3 kw 4.4 HP

M.87 Pump Speed -- Performance Relationships

Changing the velocity of a centrifugal pump will change its operating characteristics. If the speed of a pump is changed, the flow, head developed, and power requirements will change. The operating characteristics of the pump will change with speed approximately as follows:

$$\text{Flow, } Q_n = \left(\frac{N_n}{N_r}\right) Q_r$$

$$\text{Head, } H_n = \left(\frac{N_n}{N_r}\right)^2 H_r$$

$$\text{Power, } P_n = \left(\frac{N_n}{N_r}\right)^3 P_r$$

r = rated

n = now

N = Pump speed

Actually, pump efficiency does vary with speed; therefore, these formulas are not quite correct. If speeds do not vary by more than a factor of two (if the speeds are not doubled or cut in half), the results are close enough. Other factors contributing to changes in pump characteristic curves include impeller wear and roughness in pipes.

Example: To illustrate these relationships, assume a pump has a rated capacity of 600 gpm, develops 100 ft of head, and has a power requirement of 15 HP when operating at 1500 rpm. If the efficiency remains constant, what will be the operating characteristics if the speed drops to 1200 rpm?

Calculate new flow rate or capacity:

$$\text{Flow, } Q_n = \left(\frac{N_n}{N_r}\right) Q_r$$

$$= \left(\frac{1200 \text{ rpm}}{1500 \text{ rpm}}\right) 600 \text{ gpm}$$

$$= \left(\frac{4}{5}\right) 600 \text{ gpm}$$

$$= (4)\ (120 \text{ gpm})$$

$$= 480 \text{ gpm}$$

Calculate new head:

$$\text{Head, } H_n = \left(\frac{N_n}{N_r}\right)^2 H_r$$

$$= \left(\frac{1200 \text{ rpm}}{1500 \text{ rpm}}\right)^2 100 \text{ ft}$$

$$= \left(\frac{4}{5}\right)^2 100 \text{ ft}$$

$$= \left(\frac{16}{25}\right) (100 \text{ ft})$$

$$= 16\ (4 \text{ ft})$$

$$= 64 \text{ ft}$$

Calculate new power requirement:

$$\text{Power, } P_n = \left(\frac{N_n}{N_r}\right)^3 P_r$$

$$= \left(\frac{1200 \text{ rpm}}{1500 \text{ rpm}}\right)^3 15 \text{ HP}$$

$$= \left(\frac{4}{5}\right)^3 15 \text{ HP}$$

$$= \left(\frac{64}{125}\right) 15 \text{ HP}$$

$$= \left(\frac{64}{25}\right) 3 \text{ HP}$$

$$= 7.7 \text{ HP}$$

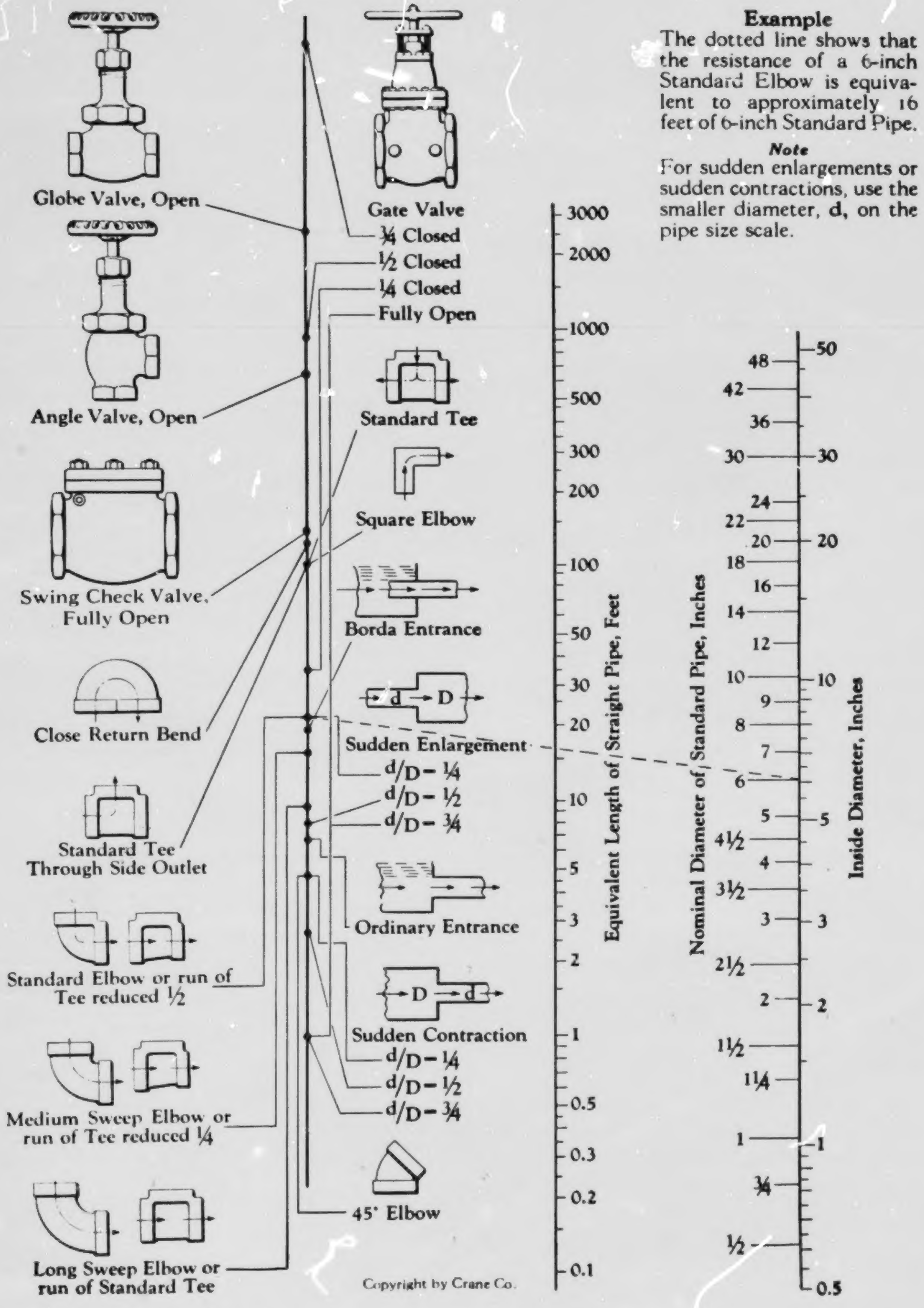
M.88 Friction or Energy Losses

Whenever water flows through pipes, valves and fittings, energy is lost due to pipe friction and due to friction in valves and fittings and the turbulence resulting from the flowing water changing its direction. To estimate the friction or energy losses resulting from water flowing in a pipe system, we need to know:

1. Water flow rate,
2. Pipe size or diameter and length,
3. Number, size and type of valve fittings.

An easy way to estimate friction or energy losses is to follow the following steps:

1. Determine the flow rate,
2. Determine the diameter and length of pipe,
3. Convert all valves and fittings to equivalent lengths of straight pipe (see Figure M.1),
4. Add up total length of equivalent straight pipe,
5. Estimate friction or energy losses by using Figure M.2. With the flow in GPM and diameter of pipe, find the friction loss per 100 feet of pipe. Multiply this value by equivalent length of straight pipe.



Example

The dotted line shows that the resistance of a 6-inch Standard Elbow is equivalent to approximately 16 feet of 6-inch Standard Pipe.

Note

For sudden enlargements or sudden contractions, use the smaller diameter, **d**, on the pipe size scale.

Fig. M.1. Resistance of valves and fittings to flow of water. (Reprinted by permission of Crane Co.)

U. S. GPM	0.5 In.		0.75 In.		1 In.		1.25 In.		1.6 In.		2 In.		2.5 In.	
	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.
10	10.56	95.9	6.02	23.0	3.71	6.86	2.15	1.77	1.58	.83	.96	.25	.67	.11
20	....	....	12.0	86.1	7.42	25.1	4.29	6.34	3.15	2.94	1.91	.87	1.34	.36
30	....	....	....	....	11.1	54.6	6.44	13.6	4.73	6.26	2.87	1.82	2.01	.75
40	....	....	....	....	14.8	95.	8.58	23.5	6.30	10.79	3.82	3.10	2.68	1.28
50	....	....	....	....	....	....	10.7	36.0	7.88	16.4	4.78	4.67	3.35	1.94
60	....	....	....	....	....	....	12.9	51.0	9.46	23.2	5.74	6.59	4.02	2.72
70	....	....	....	....	....	....	15.0	68.8	11.03	31.3	6.69	8.86	4.69	3.63
80	....	....	....	....	....	....	17.2	89.2	12.6	40.5	7.65	11.4	5.36	4.66
90	....	....	....	....	....	....	....	....	14.2	51.0	8.60	14.2	6.03	5.82
100	....	....	....	....	....	....	....	....	15.8	62.2	9.56	17.4	6.70	7.11
120	....	....	....	....	....	....	....	....	18.9	88.3	11.5	24.7	8.04	10.0
140	....	....	....	....	....	....	....	....	....	....	13.4	33.2	9.38	13.5
160	....	....	....	....	....	....	....	....	....	....	15.3	43.0	10.7	17.4
180	....	....	....	....	....	....	....	....	....	....	17.2	54.1	12.1	21.9
200	....	....	....	....	....	....	....	....	....	....	19.1	66.3	13.4	26.7
220	....	....	....	....	....	....	....	....	....	....	21.0	80.0	14.7	32.2
240	....	....	....	....	....	....	....	....	....	....	22.9	95.0	16.1	38.1
260	....	....	....	....	....	....	....	....	....	....	....	....	17.4	44.5
280	....	....	....	....	....	....	....	....	....	....	....	....	18.8	51.3
300	....	....	....	....	....	....	....	....	....	....	....	....	20.1	58.5
350	....	....	....	....	....	....	....	....	....	....	....	....	23.5	79.2

U. S. GPM	3 In.		4 In.		5 In.		6 In.		8 In.		10 In.		12 In.		14 In.		16 In.		18 In.		20 In.	
	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.	Vel.	Frict.
20	.91	.15																				
40	1.82	.55	1.02	.13																		
60	2.72	1.17	1.53	.28	.96	.08																
80	3.63	2.02	2.04	.48	1.28	.14	.91	.06														
100	4.54	3.10	2.55	.73	1.60	.20	1.13	.10														
120	5.45	4.40	3.06	1.03	1.92	.29	1.36	.13														
140	6.35	5.93	3.57	1.38	2.25	.38	1.59	.18														
160	7.26	7.71	4.08	1.78	2.57	.49	1.82	.23														
180	8.17	9.73	4.60	2.24	2.89	.61	2.04	.28														
200	9.08	11.9	5.11	2.74	3.21	.74	2.27	.35														
220	9.98	14.3	5.62	3.28	3.53	.88	2.50	.42	1.40	.10												
240	10.9	17.0	6.13	3.88	3.85	1.04	2.72	.49	1.53	.12												
260	11.8	19.8	6.64	4.54	4.17	1.20	2.95	.57	1.66	.14												
280	12.7	22.8	7.15	5.25	4.49	1.38	3.18	.66	1.79	.16												
300	13.6	26.1	7.66	6.03	4.81	1.58	3.40	.75	1.91	.18												
350	....	....	8.94	8.22	5.61	2.11	3.97	1.01	2.24	.24												
400	....	....	10.20	10.7	6.41	2.72	4.54	1.30	2.55	.30												
450	....	....	11.45	13.4	7.22	3.41	5.11	1.64	2.87	.38	1.84	.12										
500	....	....	12.8	16.6	8.02	4.16	5.67	2.02	3.19	.46	2.04	.15	1.42	.06								
550	....	....	14.0	19.9	8.82	4.98	6.24	2.42	3.51	.56	2.25	.18	1.56	.07								
600	....	....	....	....	9.62	5.88	6.81	2.84	3.83	.66	2.45	.21	1.70	.08	1.25	.04						
700	....	....	....	....	11.2	7.93	7.94	3.87	4.47	.88	2.86	.29	1.99	.12	1.46	.05						
800	....	....	....	....	12.8	10.22	9.08	5.06	5.11	1.14	3.27	.37	2.27	.15	1.67	.07						
900	....	....	....	....	14.4	12.9	10.2	6.34	5.74	1.44	3.68	.46	2.55	.18	1.88	.09						
1000	....	....	....	....	....	....	11.3	7.73	6.38	1.76	4.09	.57	2.84	.22	2.08	.11						
1100	....	....	....	....	....	....	12.5	9.80	7.02	2.14	4.49	.68	3.12	.27	2.29	.13						
1200	....	....	....	....	....	....	13.6	11.2	7.66	2.53	4.90	.81	3.40	.32	2.50	.15	1.91	.08				
1300	....	....	....	....	....	....	14.7	13.0	8.30	2.94	5.31	.95	3.69	.37	2.71	.17	2.07	.09				
1400	....	....	....	....	....	....	....	....	8.93	3.40	5.72	1.09	3.97	.43	2.92	.20	2.23	.10				
1500	....	....	....	....	....	....	....	....	9.57	3.91	6.13	1.25	4.26	.49	3.13	.23	2.34	.12				
1600	....	....	....	....	....	....	....	....	10.2	4.45	6.54	1.42	4.54	.55	3.33	.25	2.55	.13	2.02	.07		
1700	....	....	....	....	....	....	....	....	10.8	5.00	6.94	1.60	4.82	.62	3.54	.29	2.71	.15	2.15	.08		
1800	....	....	....	....	....	....	....	....	11.5	5.58	7.35	1.78	5.11	.70	3.75	.32	2.87	.16	2.27	.09		
1900	....	....	....	....	....	....	....	....	12.1	6.19	7.76	1.97	5.39	.77	3.96	.35	3.03	.18	2.40	.10		
2000	....	....	....	....	....	....	....	....	12.8	6.84	8.17	2.17	5.67	.86	4.17	.39	3.19	.20	2.52	.11		
2500	....	....	....	....	....	....	....	....	....	....	10.2	3.38	7.10	1.33	5.21	.60	3.99	.31	3.15	.17		
3000	....	....	....	....	....	....	....	....	....	....	12.3	4.79	8.51	1.88	6.25	.86	4.79	.44	3.78	.24	3.06	.14
3500	....	....	....	....	....	....	....	....	....	....	14.3	6.55	9.93	2.56	7.29	1.16	5.58	.58	4.41	.32	3.57	.19
4000	....	....	....	....	....	....	....	....	....	....	....	....	11.3	3.31	8.34	1.50	6.38	.75	5.04	.42	4.08	.24
4500	....	....	....	....	....	....	....	....	....	....	....	....	12.8	4.18	9.38	1.88	7.18	.95	5.67	.53	4.59	.31
5000	....	....	....	....	....	....	....	....	....	....	....	....	14.2	5.13	10.4	2.30	7.98	1.17	6.30	.65	5.11	.38
6000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12.5	3.31	9.57	1.66	7.56	.92	6.13	.53
7000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	14.6	4.50	11.2	2.26	8.83	1.24	7.15	.72
8000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12.8	2.96	10.09	1.61	8.17	.94
9000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	14.4	3.73	11.3	2.02	9.19	1.18
10000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12.6	2.48	10.2	1.45

No allowance has been made for age, differences in diameter, or any other abnormal condition of interior surface. Any Factor of Safety must be estimated from the local conditions and the requirements of each particular installation. For general purposes, 15% is a reasonable Factor of Safety.

Fig. M.2. Friction Loss for Water in Feet Per 100 Feet of Pipe

(Reprinted from the 10th edition of the Standards of the Hydraulic Institute, 122 East 42nd Street, New York.)

Example: Estimate the friction losses in the piping system of a lift station when the flow is 1000 GPM. The 8-inch suction line is 10 feet long and contains a 90-degree bend (long sweep elbow), a gate valve and an 8-inch by 6-inch reducer at the inlet to the pump. The 6-inch discharge line is 30 feet long and contains a check valve, a gate valve and three 90-degree bends (medium sweep elbows):

Suction Line (8-inch diameter)

Item	Equivalent Length, ft
1. Length of pipe	10
2. 90-degree bend	14
3. Gate valve	4
4. 8 in by 6 in reducer	17
5. Ordinary entrance	12
Total equivalent length	57 ft

Friction loss (Fig. M.2) = 1.76 ft/100 ft of pipe

Discharge Line (6-inch diameter)

Item	Equivalent Length, ft
1. Length of pipe	30
2. Check valve	38
3. Gate valve	4
4. Three 90-degree bends (3) (14)	42
Total equivalent length	114 ft

Friction loss (Fig. M.2) = 7.73 ft/100 ft of pipe

Estimate total friction losses in pumping system for a flow of 1000 GPM.

Suction

Loss = (1.76 ft/100 ft)(57 ft) = 1.0 ft

Discharge

Loss = (7.73 ft/100 ft)(115 ft) = 8.8 ft

Total friction losses, ft = 9.8 ft

M.9 SOLUTIONS TO PROBLEMS

In this section typical math problems that have to be solved by wastewater collection system workers are presented. If a particular problem is too difficult, go to the next problem and try it. For example, if the problems on excavation become too difficult, try the problems on electricity.

A. Population Equivalent

1. A 24-inch sewer carries an average daily flow of 5 MGD. If the average daily flow per person from the area served is 100 gpcd*(gallons per capita or person per day), how many people discharge into the wastewater collection system?

Known		Unknown
Diameter, in	= 24 in	Pop. served, persons
Flow, MGD	= 5 MGD	
or	= 5,000,000 gal/day	
Pop. Equiv., gpcd	= 100 gpcd	

How many people discharge into collection system?

$$\text{Pop. served, persons} = \frac{\text{Flow, gal/day}}{\text{Pop. Equiv., gal/person/day}}$$

$$= \frac{5{,}000{,}000 \text{ gal/day}}{100 \text{ gal/person/day}}$$

$$= \underline{\underline{50{,}000 \text{ persons}}}$$

---

*Usually about 70% of the water supply rate.

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Analysis of Results

Calculated Pop	Actual Pop.	Comments
50,000	50,820	Results appear OK
50,000	38,130	Since calculated population is considerably greater than actual, either there is considerable industrial discharge or inflow/infiltration. Find the cause of additional flow.
50,000	63,617	Since calculated population is considerably less than actual population, apparently there is considerable exfiltration. Find the cause or location of exfiltration.

2. An industry discharges an average of 5,320 gallons per day. What is the population equivalent from this industry? Assume a population equivalent flow of 100 gpcd.

Known			Unknown
Average flow, gal/day	=	5,320 gal/day	Pop. Equiv., persons
Pop. Equiv., gpcd	=	100 gpcd	

What is the population equivalent from this industry?

$$\text{Pop. Equiv., persons} = \frac{\text{Flow, gal/day}}{\text{Pop. Equiv., gal/person/day}}$$

$$= \frac{5{,}320 \text{ gal/day}}{100 \text{ gal/person/day}}$$

$$= 53.2$$

$$\text{or} \quad = \underline{\underline{53 \text{ persons}}}$$

B. Velocity and Flow

3. Estimate the velocity of wastewater flowing in a 12-inch sewer. A red dye is poured into an upstream manhole. Three minutes later the dye first appears in a manhole 400 feet downstream. The dye disappears 3 minutes and 40 seconds after the dye is poured into the upstream manhole.

Known	Unknown
Diameter, in = 12 in	Velocity, ft/sec
Time, sec t_1 = 3 min	
Time, sec t_2 = 3 min 40 sec	
Distance, ft = 400 feet	

Convert travel time to seconds.

Time, sec. t_1 = 3 min
= (3 min)(60 sec/min)
= 180 sec

Ave. Time, Sec = 1/2 $(t_1 + t_2)$
= 1/2 (180 sec + 220 sec)
200 sec

Time, sec t_2 = 3 min 40 sec
= (3 min) (60 sec/min) + 40 sec
= 180 sec + 40 sec
= 220 sec

Estimate velocity in feet per second

$$\text{Velocity, ft/sec} = \frac{\text{Distance, ft}}{\text{Ave. Time, sec}}$$

$$= \frac{400 \text{ ft}}{200 \text{ sec}}$$

$$= \underline{\underline{2.0 \text{ ft/sec}}}$$

Analysis of Results

Velocity is a minimum recommended velocity of 2 fps. Problems of solids deposition could result at low flows.

4. A float (marked stick) is dropped into a manhole to estimate the velocity of the wastewater. Two minutes and 30 seconds later the float arrives in a manhole 450 feet downstream.

Known		Unknown
Time, sec = 2 min 30 sec		Velocity, ft/sec
Distance, ft = 450 ft		

Convert travel time to seconds.

$$
\begin{aligned}
\text{Time, sec} &= 2 \text{ min } 30 \text{ sec} \\
&= (2 \text{ min})(60 \text{ sec/min}) + 30 \text{ sec} \\
&= 120 \text{ sec} + 30 \text{ sec} \\
&= 150 \text{ sec}
\end{aligned}
$$

Estimate velocity in feet per second.

$$
\begin{aligned}
\text{Velocity, ft/sec} &= \frac{\text{Distance, ft}}{\text{Time, sec}} \\
&= \frac{450 \text{ ft}}{150 \text{ sec}} \\
&= \underline{\underline{3.0 \text{ ft/sec}}}
\end{aligned}
$$

NOTE - Velocity of floats is often 10 to 15 percent higher than the average velocity.

Convert float velocity to average velocity. Assume float velocity 10 percent too high.

$$
\begin{aligned}
\text{Ave. Vel., ft/sec} &= \text{Float vel., ft/sec} \\
&\quad - (\text{Float vel., ft/sec})(\text{fraction too high}) \\
&= 3.0 \text{ ft/sec} - (3.0 \text{ ft/sec})\left(\frac{10\%}{100\%}\right) \\
&= 3.0 \text{ ft/sec} - 3.0 \text{ ft/sec } (0.1) \\
&= 3.0 \text{ ft/sec} - 0.3 \text{ ft/sec} \\
&= \underline{\underline{2.7 \text{ ft/sec}}}
\end{aligned}
$$

5. Determine the flow in a 12-inch sewer flowing full if the average velocity is 2 fps.

Known		Unknown
Diameter, in	= 12 in	Flow, cfs
Velocity, ft/sec	= 2 ft/sec	

Calculate area of 12-inch sewer.

$$\text{Area, sq in} = \frac{\pi}{4} D^2$$

$$= \frac{3.14}{4} (12 \text{ in})^2$$

$$= (0.785)(144 \text{ sq in})$$

$$= 113 \text{ sq in}$$

or

$$\text{Area, sq ft} = \frac{(\text{Area, sq in})}{(144 \text{ sq in/sq ft})}$$

$$= \frac{113 \text{ sq in}}{144 \text{ sq in/sq ft}}$$

$$= 0.785 \text{ sq ft}$$

Determine flow in cubic feet per second.

$$Q = AV$$

or

$$\text{Flow, cfs} = (\text{Area, sq ft})(\text{Velocity, ft/sec})$$

$$= (0.785 \text{ sq ft})(2 \text{ ft/sec})$$

$$= \underline{\underline{1.57 \text{ cu ft/sec}}}$$

6. Convert a flow of 2 cfs to million gallons per day (MGD) and gallons per minute (GPM).

Known	Unknown
Flow, cfs = 2 cfs	Flow, MGD
	Flow, GPM

Conversion factors

$$1 \text{ cfs} = 0.646 \text{ MGD} = 449 \text{ GPM}$$

or

$$1.547 \text{ cfs} = 1 \text{ MGD} = 694 \text{ GPM}$$

Convert 2 cfs to flow in MGD.

$$\text{Flow, MGD} = (\text{Flow, cfs})\frac{(0.646 \text{ MGD})}{1 \text{ cfs}}$$

$$= (2 \text{ cfs})\frac{(0.646 \text{ MGD})}{1 \text{ cfs}}$$

$$= \underline{\underline{1.292 \text{ MGD}}}$$

$$\text{Flow, GPM} = (\text{Flow, cfs})\frac{(449 \text{ GPM})}{1 \text{ cfs}}$$

$$= (2 \text{ cfs})\frac{(449 \text{ GPM})}{1 \text{ cfs}}$$

$$= \underline{\underline{898 \text{ GPM}}}$$

7. What was the average daily flow for a lift station given the following flow totalizer reading?

8:00 a.m., Monday, August 11	113,428,731 gallons
8:00 a.m., Monday, August 18	121,987,566 gallons

Known	Unknown
Totalizer Readings, gallons	Ave. Flow, MGD
Time, days = 7 days	

Determine total flow for 7 days in gallons.

Final Reading, gal = 121,987,566 gal

Initial Reading, gal = $\underline{113{,}428{,}731 \text{ gal}}$

Total flow, gal = 8,558,835 gal

or Total flow, MG = 8.559 MG

Calculate average flow, MGD

$$\text{Ave. flow, MGD} = \frac{\text{Total flow, MG}}{\text{Time, days}}$$

$$= \frac{8.559 \text{ MG}}{7 \text{ days}}$$

$$= \underline{\underline{1.22 \text{ MGD}}}$$

8. Estimate the average daily flow for a lift station given the following daily flow readings:

Day	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
Flow, MG or MGD*	1.68	1.53	1.21	1.16	1.05	1.47	0.90

Known	Unknown
Daily flows, MGD	Ave. daily flow, MGD

Estimate average daily flow, MGD.

$$\text{Ave. daily flow, MGD} = \frac{\text{Sum of daily flows, MGD}}{\text{Number of daily flows}}$$

$$= \frac{1.68+1.53+1.21+1.16+1.05+1.47+0.90}{7}$$

$$= \frac{9.00\text{ MGD}}{7}$$

$$= 1.286\text{ MGD}$$

$$= \underline{\underline{1.29\text{ MGD}}}$$

*NOTE: 1.68 MG flowed during one day so we had a flow of 1.68 MGD.

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C. Pipes

9. A piece of pipe is 23 feet long and is to be cut into 4 equal pieces. Each piece will be ____ ft ____ inches long.

Known	Unknown
Length, ft = 23 ft	Length, ft and inches
Want 4 equal pieces	

Determine length in feet and then feet and inches.

$$\text{Length, ft} = \frac{\text{Total length, ft}}{\text{Number of equal pieces}}$$

$$= \frac{23 \text{ feet}}{4 \text{ pieces}}$$

$$= 5.75 \text{ ft}$$

or

$$\text{Length, ft \& in} = 5 \text{ ft} + (0.75 \text{ ft})(12 \text{ in/ft})$$

$$= \underline{\underline{5 \text{ ft } 9 \text{ in}}}$$

10. A sewer has failed and 127 feet of 8-inch pipe must be replaced. How many 5-foot sections of pipe will be required?

Known	Unknown
Length, ft = 127 ft	Number of sections
Section, ft = 5 ft	

Calculate number of sections needed

$$\text{No. of sections} = \frac{\text{Total length, ft}}{\text{Length, ft/section}}$$

$$= \frac{127 \text{ ft}}{5 \text{ ft/section}}$$

$$= 25.4 \text{ sections}$$

$$= \underline{\underline{26 \text{ sections needed}}}$$

11. A sewer with a 12-inch diameter has how many times more carrying capacity than a 4-inch diameter sewer? Assume the velocity is the same in each sewer.

Known	Unknown
Diameter, in = 12 in	How many times more carrying capacity?
Diameter, in = 4 in	
Velocity same in each sewer	

Determine how many times more carrying capacity.

$$Q = A\,V \quad \text{and} \quad A = 0.785\,D^2$$

$$\begin{aligned}
\frac{\text{12 in diameter}}{\text{4 in diameter}} &= \frac{\text{12 inch pipe Q}}{\text{4 inch pipe Q}} \\
&= \frac{A\,V}{A\,V} \\
&= \frac{\cancel{0.785}\,(12\text{ in})^2\,\cancel{V}}{\cancel{0.785}\,(4\text{ in})^2\,\cancel{V}} \\
&= \frac{(12\text{ in})^2}{(4\text{ in})^2} \\
&= \frac{144}{16} \\
&= \underline{\underline{9\text{ times}}}
\end{aligned}$$

or

12-inch sewer has 9 times capacity of 4-inch sewer.

D. Slope or Grade

12. If the total fall in a ditch is 14 feet in 1000 feet, what is the grade in ft/ft and in percent?

Known	Unknown
Fall, ft = 14 ft	Grade, ft/ft
Length, ft = 1000 ft	Grade, %

Calculate grade.

$$\text{Grade, ft/ft} = \frac{\text{Rise, ft}}{\text{Run, ft}}$$

$$= \frac{14 \text{ ft}}{1000 \text{ ft}}$$

$$= \underline{0.014 \text{ ft/ft}}$$

or

$$\text{Grade, \%} = (0.014 \text{ ft/ft})(100\%)$$

$$= \underline{\underline{1.4\%}}$$

13. How many feet drop in 400 feet of 8-inch sewer with a 0.045 ft/ft slope?

Known	Unknown
Diameter, in = 8 in	Drop, ft
Length, ft = 400 ft	
Slope = 0.045 ft/ft	

Calculate drop in feet.

$$\text{Slope, ft/ft} = \frac{\text{Rise, ft}}{\text{Run, ft}}$$

Rearrange equation.

$$\text{Rise, ft} = (\text{Slope, ft/ft})(\text{Run, ft})$$

$$= (0.045 \text{ ft/ft})(400 \text{ ft})$$

$$= \underline{\underline{18.0 \text{ ft}}}$$

14. What is the slope on an 8-inch sewer that is 400 feet long if the invert elevation of the upstream manhole is 428.31 feet and the invert elevation of the downstream manhole is 423.89 feet?

Known		Unknown
Diameter, In = 8 in		Slope, ft/ft
Length, ft = 400 ft		
Upstream MH = 428.31 ft		
Downstream MH = 423.89 ft		

Find difference in elevation or drop between manholes.

$$\begin{array}{rcr} \text{Upstream MH} & = & 428.31\text{ ft} \\ \text{Downstream MH} & = & \underline{423.89\text{ ft}} \\ \text{Drop, ft} & = & 4.42\text{ ft} \end{array}$$

Calculate slope.

$$\text{Slope, ft/ft} = \frac{\text{Rise, ft}}{\text{Run, ft}}$$

$$= \frac{4.42\text{ ft}}{400\text{ ft}}$$

$$= 0.01105$$

$$= \underline{\underline{0.011\text{ ft/ft}}}$$

15. A 10-inch sewer has been televised and the footage meter between two manholes indicates the distance is 437 feet. An actual field measurement verifies the distance shown on the plans of 400 feet.

   a. What is the percent error in the length?

   b. If the TV camera was pulled from the upstream to the downstream manhole, what is the distance from each manhole to a broken pipe at distance 328 feet?

Known		Unknown
Diameter, in	= 10 in	a. Percent error
Meter distance, ft	= 437 ft	b. Location of broken pipe
Actual distance, ft	= 400 ft	
Broken pipe, ft	= 328 ft	

a. Calculate percent error.

$$\text{Error, \%} = \frac{(\text{Meter dist., ft} - \text{Actual dist., ft})\ 100\%}{\text{Actual dist., ft}}$$

$$= \frac{(437\text{ ft} - 400\text{ ft})\ 100\%}{400\text{ ft}}$$

$$= \frac{(37\text{ ft})(100\%)}{400\text{ ft}}$$

$$= \underline{\underline{9.25\%\text{ error}}}$$

NOTE: Error is greater than 1 percent so all distances in log book must be corrected. Footage meter should be recalibrated.

b. Determine location of broken pipe.

$$\text{Location, ft from Upper MH} = \frac{(\text{Meter from upper MH, ft})(\text{Actual total, ft})}{(\text{Meter Total, ft})}$$

$$= \frac{(328\ \text{ft})(400\ \text{ft})}{(437\ \text{ft})}$$

$$= \frac{131{,}200\ \text{ft}}{437}$$

$$= \underline{\underline{300\ \text{ft}}}$$

$$\text{Location, ft from Lower MH} = \frac{(\text{Meter from lower MH, ft})(\text{Actual total, ft})}{(\text{Meter Total, ft})}$$

$$= \frac{(437\ \text{ft} - 328\ \text{ft})(400\ \text{ft})}{(437\ \text{ft})}$$

$$= \frac{(109\ \text{ft})(400\ \text{ft})}{437\ \text{ft}}$$

$$= \frac{43{,}600\ \text{ft}}{437\ \text{ft}}$$

$$= \underline{\underline{100\ \text{ft}}}$$

NOTE: Distance from upper and lower manholes to broken pipe (300 ft + 100 ft = 400 ft) is equal to the actual distance so the calculations check.

E. Leak Test

16. An 8-inch sewer 400 feet long is given a water leak test. The downstream manhole is plugged where the line enters the manhole. There are no service lines connected to the test line. At 9:00 a.m. in the morning the 36-inch upstream manhole was filled to the bottom of the cone. By 5:00 p.m. the water had dropped 4.0 feet. Calculate the leakage in terms of gallons per day per inch of sewer diameter per mile of sewer.

Known			Unknown
Diameter, in	=	8 in	Leakage in gpd/in/mi
Length, ft	=	400 ft	
Time, hr	=	8 hr	
Diameter, ft	=	3 ft	
Height, ft	=	4 ft	

Calculate the volume of water that leaked.

$$\text{Volume, cu ft} = (\text{Area, sq ft})(\text{Height, ft})$$

$$= (0.785)(3\text{ ft})^2(4.0\text{ ft})$$

$$= 28.27\text{ cu ft}$$

$$\text{Volume, gal} = (28.27\text{ cu ft})(7.48\text{ gal/cu ft})$$

$$= 211.5\text{ gal}$$

Calculate leakage in gallons per day.

$$\text{Leakage, gpd} = \frac{\text{Volume, gal}}{\text{Time, day}}$$

$$= \frac{(211.5\text{ gal})(24\text{ hr/day})}{(8\text{ hr})}$$

$$= 634.5\text{ gpd}$$

Calculate leakage in gpd/inch of sewer.

$$\text{Leakage, gpd/in} = \frac{\text{Leakage, gpd}}{\text{Sewer diameter, in}}$$

$$= \frac{634.5\ \text{gpd}}{8\ \text{in}}$$

$$= 79.3\ \text{gpd/in}$$

Calculate leakage in gpd/in/mile of sewer.

$$\text{Leakage, gpd/in/mi} = \frac{(79.3\ \text{gpd/in})(5280\ \text{ft/mi})}{(\text{Length, ft})}$$

$$= \frac{(79.3\ \text{gpd/in})(5280\ \text{ft/mi})}{400\ \text{ft}}$$

$$= 1047\ \text{gpd/in/mi}$$

NOTE: Maximum allowable leakage is usually 250 to 500 gpd/inch of sewer diameter/mile of sewer. Therefore sewer fails leak test. There should be very little leakage from a properly constructed sewer. Try to find all leaks and correct them.

F. Map and Blueprint Reading

17. The distance between two manholes on a map is measured as 15/16 of an inch. Scale for the map is 1 inch equals 800 feet. Estimate the actual distance between the two manholes.

Known			Unknown
Distance, in	=	15/16 in	Actual distance, ft
Scale, 1 in	=	800 ft	

Estimate actual distance in feet.

$$\frac{\text{Actual distance, ft}}{\text{Measure distance, in}} = \frac{800\text{ ft}}{1\text{ inch}}$$

$$\text{Actual distance, ft} = \frac{(800\text{ ft})(15/16\text{ in})}{(1\text{ in})}$$

$$= (800\text{ ft})\frac{(15)}{16}$$

$$= \frac{12000}{16}$$

$$= \underline{\underline{750\text{ ft}}}$$

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G. Chemical Doses

Chlorination

18. Chlorine Demand

Determine the chlorine demand* of an effluent from a wastewater treatment plant if the chlorine dose is 10.0 mg/l and the chlorine residual is 1.1 mg/l.

Known	Unknown
Chlorine Dose = 10.0 mg/l	Chlorine Demand, mg/l
Chlorine Residual = 1.1 mg/l	

Chlorine Demand, mg/l = Chlor. Dose, mg/l - Chlor. Resid. mg/l

= 10.0 mg/l - 1.1 mg/l

= 8.9 mg/l

19. Chlorine Feed Rate

To control hydrogen sulfide and odors in an 8-inch sewer, the chlorine dose must be 10 mg/l when the flow is 0.37 MGD. Determine the chlorinator setting (feed rate) in pounds per day.

Known	Unknown
Dose = 10 mg/l	Chlorinator Setting, lbs/day
Flow = 0.37 MGD	

Chlorine Feed Rate, lbs/day = (Dose, mg/l)(Flow, MGD)(8.34 lb/gal)

= (10 mg/l)(0.37 MGD)(8.34 lb/gal)

= 30.9

or

= 31 lbs/day

---

*"Standard Methods" uses the term chlorine demand when referring to stabilized water such as a domestic water supply and the term chlorination requirement when referring to wastewater.

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Root Control

20. Quantity of Chemicals

A company contends their product is effective in controlling roots at a concentration of 100 mg/l if the contact time is 30 minutes. How many pounds of chemicals would be required assuming perfect mixing if 400 feet of 8-inch sewer were to be treated?

Known		Unknown
Concentration, mg/l = 100 mg/l		Chemical, lbs
Contact Time, min = 30 min		
Diameter, in = 8 in		
Length, ft = 400 ft		

Determine volume of sewer

$$\text{Volume, cu ft} = (0.785)(\text{Diam, ft})^2(\text{Length, ft})$$

$$= \frac{(0.785)(8\text{ in})^2(400\text{ ft})}{(12\text{ in/ft})^2}$$

$$= 139.63\text{ cu ft}$$

$$\text{Volume, gal} = (139.63\text{ cu ft})(7.48\text{ gal/cu ft})$$

$$= 1044.4\text{ gal}$$

$$= 0.0010444\text{ MG}$$

Calculate weight of water in sewer.

Weight, lbs = (Volume, gal)(8.34 lb/gal)

= (0.0010444 MG)(8.34 lb/gal)

= 0.0087 M lb

NOTE: 1 mg/l = 1 part/million parts = 1 lb/M lbs for water.

Calculate required pounds of chemicals.

$$100\ \text{mg/l} = \frac{\text{Chemicals, lbs}}{\text{Water, M lbs}}$$

Chemicals, lbs = (100 mg/l)(Water, M lbs)

= (100 mg/l)(0.0087 M lb)

= $\underline{\underline{\text{0.87 lbs}}}$

Order one pound of chemicals and pay the company if the chemicals work as claimed.

H. Excavation and Paving

21. A trench 3 feet wide, 8 feet deep and 70 feet long is to be filled with sand.

    a. How many cubic feet of sand required?

    b. How many cubic yards of sand?

    c. How many 5 cubic yard dump truck loads?

    d. How many tons of sand carried by each truck if sand weighs 144 lbs/cu ft?

Known			Unknown
Width, ft	=	3 ft	a. Sand, cu ft
Depth, ft	=	8 ft	b. Sand, cu yd
Length, ft	=	70 ft	c. Number of trucks
Sand, lbs/cu ft	=	144 lbs/cu ft	d. Truck load, tons

Find volume of trench and volume of sand.

a. Volume, cu ft = (Length, ft)(Width, ft)(Depth, ft)

= (70 ft)(3 ft)(8ft)

= 1680 cu ft

b. Volume, cu yd = $\frac{\text{(Volume, cu ft)}}{\text{(27 cu ft/cu yd)}}$

= $\frac{\text{1680 cu ft}}{\text{27 cu ft/cu yd}}$

= 62.22 cu yd

Determine number of 5 cu yd truck loads required.

c. No. of truck loads = $\frac{\text{Volume, cu yd}}{\text{Truck capacity, cu yd/load}}$

$$= \frac{62.22 \text{ cu yd}}{5 \text{ cu yd/load}}$$

$$= \underline{\underline{12.44 \text{ loads}}}$$

Thirteen truck loads will be required.

Calculate the truck load in tons.

d. Truck Load, tons $= \frac{(\text{Truck Cap., cu yd})(\text{Sand, lbs/cu ft})(27 \text{ cu ft/cu yd})}{(2000 \text{ lbs/ton})}$

$$= \frac{(5 \text{ cu yd})(144 \text{ lbs/cu ft})(27 \text{ cu ft/cu yd})}{2000 \text{ lbs/ton}}$$

$$= \underline{\underline{9.72 \text{ tons}}}$$

22. How many cubic yards of AC paving material will be required to pave over a trench 2400-feet long and 3-feet wide using a 3-inch deep patch?

Known

Length, ft = 2400 ft

Width, ft = 3 ft

Depth, in = 3 in

Unknown

Paving, cu yards

Find volume of paving in cu ft.

$$\text{Paving, cu ft} = (\text{Length, ft})(\text{Width, ft})(\text{Depth, ft})$$

$$= \frac{(2400\ \text{ft})(3\ \text{ft})(3\ \text{in})}{(12\ \text{in/ft})}$$

$$= 1800\ \text{cu ft}$$

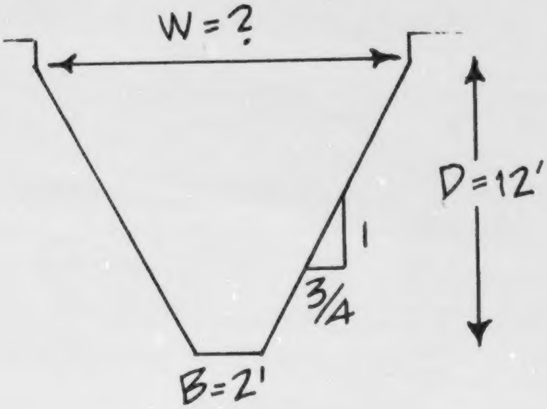
Calculate volume of paving in cu yd.

$$\text{Paving, cu yd} = \frac{1800\ \text{cu ft}}{27\ \text{cu ft/cu yd}}$$

$$= \underline{\underline{66.7\ \text{cu yd}}}$$

23. If a sewer trench is 2-feet wide at the bottom, 12 feet deep, and the walls are sloped at 3/4 horizontal to 1 vertical, how wide is the trench at the ground surface?

Known			Unknown
Trench base, ft	=	2 ft	Trench width, ft at top
Trench depth, ft	=	12 ft	
Trench slope, S	=	3/4 ft horiz. to 1 ft vert.	



Determine trench width at top.

$$\text{Slope, S} = \frac{\text{Rise}}{\text{Run}}$$

$$= \frac{1}{3/4}$$

$$= 4/3$$

$$\text{Width, ft} = \text{Base, ft} + (2 \text{ sides})\frac{(\text{Depth, ft})}{\text{Slope}}$$

$$= 2 \text{ ft} + (2)\frac{(12 \text{ ft})}{4/3}$$

$$= 2 \text{ ft} + (2)(12 \text{ ft})\frac{(3)}{4}$$

$$= 2 \text{ ft} + 18 \text{ ft}$$

$$= \underline{\underline{20 \text{ ft}}}$$

24. Prepare a sewer grade (cut) sheet for a sewer laid on a 0.5% grade with the given stake elevations and an invert grade of 100.00 feet for station 0+00.

Station	Stake Elevation	Invert Grade	Cut
0+00	105.60	100.00	______
0+50	106.12	______	______
1+00	106.75	______	______
1+50	107.37	______	______
2+00	108.02	______	______
2+50	108.41	______	______
3+00	108.98	______	______
3+50	109.22	______	______
3+91	108.69	______	______

To solve this problem, complete the above cut sheet by first calculating the invert grades.

$$\text{Grade, ft/ft} = \frac{\text{Grade, \%}}{100\%}$$

$$= \frac{0.5\%}{100\%}$$

$$= 0.005 \text{ ft/ft}$$

$$\text{or} \quad = (0.005 \text{ ft/ft})\left(\frac{100 \text{ ft}}{100 \text{ ft}}\right)$$

$$= 0.5 \text{ ft/100 ft}$$

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Since the grade is 0.5 ft per 100 ft, increase the invert grade by 0.25 ft for each 50 ft, or multiply the distance times the grade.

Invert Grade, ft = 100.00 ft + (Distance, ft)(Grade, ft/ft)

= 100.00 ft + (50 ft)(0.005 ft/ft)

= 100.00 ft + 0.25 ft = 100.25 ft

Station

1+00 = 100.00 ft + (100)(0.005) = 100.50

1+50 = 100.00 ft + (150)(0.005) = 100.75

3+91 = 100.00 ft + (391)(0.005) = 101.96

To determine cut, subtract invert from stake elevation.

Station	Stake	-	Invert	=	Cut
0+00	105.60	-	100.00	=	5.60
0+50	106.12	-	100.25	=	5.87
1+00	106.75	-	100.50	=	6.25
3+91	108.69	-	101.96	=	6.73

Completed sewer cut sheet.

Station	Stake Elevation	Invert Grade	Cut
0+00	105.60	100.00	5.60
0+50	106.12	100.25	5.87
1+00	106.75	100.50	6.25
1+50	107.37	100.75	6.62
2+00	108.02	101.00	7.02
2+50	108.41	101.25	7.16
3+00	108.98	101.50	7.48
3+50	109.22	101.75	7.47
3+91	108.69	101.96	6.73

I. Electricity

25. A 12-volt battery operates a radio with a 4-ohm resistance. What amp fuse is necessary?

Known			Unknown
EMF, volts	=	12 volts	Current, amps
Resist., ohms	=	4 ohms	

Calculate the current, amps.

$$\text{Current, amps} = \frac{\text{EMF, volts}}{\text{Resistance, ohms}}$$

$$= \frac{12 \text{ volts}}{4 \text{ ohms}}$$

$$= \underline{\underline{3 \text{ amps}}}$$

A three-amp fuse is necessary.

26. A 30-ohm resistor requires a current of 8 amps. How many watts will the resistor draw?

Known			Unknown
Resist., ohms	=	30 ohms	Power, watts
Current, amps	=	8 amps	

Calculate the power in watts.

$$\text{Power, watts} = (\text{I, amps})^2(\text{R, ohms})$$

$$= (8 \text{ amps})^2(30 \text{ ohms})$$

$$= \underline{\underline{1920 \text{ watts}}}$$

27. A pump motor is supplied with 220 volts and draws 15 amps. What is the horsepower output of the motor if the power factor is 0.8 and the motor efficiency is 90%?

Known			Unknown
EMF, volts	=	220 volts	Power, watts
Current, amps	=	15 amps	Output, horsepower
Power factor	=	0.8	
Efficiency, %	=	90%	

Calculate the power in watts.

$$\text{P, watts} = (\text{E, volts})(\text{I, amps})$$

$$= (220 \text{ volts})(15 \text{ amps})$$

$$= \underline{\underline{3{,}300 \text{ watts}}}$$

Calculate the output horsepower.

$$\text{Output, hp} = \frac{(\text{P, watts})(\text{Power factor})(\text{Efficiency})}{746 \text{ watts/hp}}$$

$$= \frac{(3{,}300 \text{ watts})(0.8)(0.9)}{746 \text{ watts/hp}}$$

$$= \underline{\underline{3.18 \text{ hp}}}$$

Use a 3.5 horsepower motor.

J. Pumps

28. Determine the water horsepower delivered by a pump if the flow is 100 gallons per minute and the total dynamic head is 70 feet.

Known	Unknown
Flow, GPM = 100 GPM	Water hp, hp
TDH, ft = 70 ft	

Calculate water horsepower.

$$\text{Water hp} = \frac{(\text{Q, GPM})(\text{TDH, ft})}{3960} = \frac{(\text{Q, cfs})(62.4\ \text{lb/cu ft})(\text{H, ft})}{550\ \text{ft-lb/sec-hp}}$$

$$= \frac{(100\ \text{GPM})(70\ \text{ft})}{3960}$$

$$= \underline{\underline{1.77\ \text{hp}}}$$

29. How efficient is a pump if the water horsepower is 1.77 hp and the brake horsepower is 2.50 hp?

Known	Unknown
Water hp = 1.77 hp	Pump efficiency, %
Brake hp = 2.50 hp	

Calculate the pump efficiency.

$$\text{Pump efficiency, \%} = \frac{(\text{Water hp})(100\%)}{\text{Brake hp}}$$

$$= \frac{(1.77\ \text{hp})(100\%)}{2.50\ \text{hp}}$$

$$= \underline{\underline{71\%}}$$

30. If a pump motor draws 2000 watts and the water horsepower from the pump is 1.77 hp, what is the overall efficiency of the system?

Known		Unknown
Pump motor, watts	= 2000 watts	Overall Eff., %
Water hp	= 1.77 hp	

Find input horsepower.

$$\text{Input hp} = \frac{\text{Power drawn, watts}}{746\ \text{watts/hp}}$$

$$= \frac{2000\ \text{watts}}{746\ \text{watts/hp}}$$

$$= 2.68\ \text{hp}$$

Calculate overall efficiency.

$$\text{Overall eff., \%} = \frac{\text{Output, hp}}{\text{Input, hp}}$$

$$= \frac{(1.77\ \text{hp})\ 100\%}{2.68\ \text{hp}}$$

$$= \underline{\underline{66\%}}$$

31. A pump has a rated capacity of 500 GPM, develops a head of 120 feet, and has a power requirement of 20 hp when operating at 900 rpm. If the efficiency remains constant, what will be the operating characteristics if the speed increases to 1200 rpm?

Known			Unknown
Flow, GPM	=	500 GPM	Q_n, GPM
Head, ft	=	120 ft	H_n, GPM
Power, hp	=	20 hp	P_n, GPM
N_r, rpm	=	900 rpm	
N_n, rpm	=	1200 rpm	

Calculate the new flow rate or capacity.

$$Q_n\text{, GPM} = \left(\frac{N_n}{N_r}\right) Q_r$$

$$= \left(\frac{1200 \text{ rpm}}{900 \text{ rpm}}\right) 500 \text{ GPM}$$

$$= \left(\frac{4}{3}\right) 500 \text{ GPM}$$

$$= \underline{\underline{667 \text{ GPM}}}$$

Calculate the new head.

$$H_n\text{, ft} = \left(\frac{N_n}{N_r}\right)^2 H_r$$

$$= \left(\frac{1200 \text{ rpm}}{900 \text{ rpm}}\right)^2 120 \text{ ft}$$

$$= \left(\frac{4}{3}\right)^2 120 \text{ ft}$$

$$= \underline{\underline{213.3 \text{ ft}}}$$

Calculate the new power requirement.

$$P_n\text{, hp} = \left(\frac{N_n}{N_r}\right)^3 P_r$$

$$= \left(\frac{1200 \text{ rpm}}{900 \text{ rpm}}\right)^3 20 \text{ hp}$$

$$= \left(\frac{4}{3}\right)^3 20 \text{ hp}$$

$$= \underline{\underline{47.4 \text{ hp}}}$$

32. The rate at which a wet well fills can be used to calibrate a flow meter. The same procedure can be used to determine the capacity of a pump. Determine the pump capacity in GPM if an 8-foot long and 6-foot wide wet well is lowered 4 feet in 5 minutes. Assume no additional water flows into the wet well.

Known			Unknown
Length, ft	=	8 ft	Flow, GPM
Width, ft	=	6 ft	
Depth, ft	=	4 ft	
Time, min	=	5 min	

Determine volume of water pumped.

Volume, cu ft = (Length, ft)(Width, ft)(Depth, ft)

= (8ft)(6ft)(4ft)

= 192 cu ft

Volume, gal = (192 cu ft)(7.48 gal/cu ft)

= 1436 gal

Calculate pumping rate.

$$\text{Flow, GPM} = \frac{\text{Volume, gal}}{\text{Time, min}}$$

$$= \frac{1436 \text{ gal}}{5 \text{ min}}$$

$$= \underline{\underline{287 \text{ GPM}}}$$

33. Water is flowing into a wet well at a rate of 342 GPM. The level of the wet well is rising at a rate of 28 GPM. What is the pump capacity under these conditions?

Known	Unknown
Inflow, GPM = 342 GPM	Pump, GPM
Rise, GPM = 28 GPM	

Determine pump capacity.

Inflow = Outflow ± Storage

Inflow, GPM = Pump, GPM + Rise, GPM

or

Pump, GPM = Inflow, GPM - Rise, GPM

= 342 GPM - 28 GPM

= 314 GPM

34. A lift station receives wastewater from a 24-inch intercepting sewer with a capacity of 5 MGD. The elevation of the sewer invert entering the wet well is 51.80 feet. The elevation of lowest manhole lid on the intercepting sewer is 75.20 feet and the elevation of the lowest home plumbing fixture that could overflow and cause damage is 76.50 feet. The slope of the intercepting sewer is 1.5 ft/1000 ft. If the lift station pumps fail or there is a power outage, how much time is available to get the lift station back on the line if the inflow is 2.5 MGD?

Known		Unknown
Diameter, in	= 24 in	Time, hour
Sewer capacity, MGD	= 5 MGD	
Sewer flow, MGD	= 2.5 MGD	
Elev. of invert to L.S.	= 51.80 ft	
Elev. of MH lid	= 75.20 ft	
Elev. of fixture	= 76.50 ft	
Sewer slope	= 1.5 ft/1000 ft	

Procedure

1. Calculate the storage capacity in the intercepting sewer when it is flowing at 2.5 MGD. Use only the capacity in the sewer between the wet well and the lowest manhole lid. A safety factor will be provided by any connecting sewers and a portion of the sewer whose crown elevation is above the lowest manhole lid but whose invert is below the elevation of the lid.

2. Calculate the time to fill the intercepting sewer by dividing the flow into the storage capacity.

Determine elevation at crown of sewer entering wet well.

Elevation of sewer invert = 51.80 ft

Diameter of sewer = 2.00 ft

Elevation of crown of sewer = 53.80 ft

Calculate the elevation of vertical distance the water can rise before overflowing from the lowest manhole lid. Use crown of sewer rather than water surface at wet well because the empty portion of the sewer is the space or storage capacity that will be filled with water.

Elevation of manhole lid = 75.20 ft

Elevation of crown of sewer = 53.80 ft

Difference in elevation = 21.40 ft

Use 21 feet with a 0.4 foot additional safety factor.

Estimate length of sewer that could be filled before the lowest manhole starts overflowing.

$$\text{Length of sewer, ft} = \frac{\text{Diff. in elev., ft}}{\text{Sewer slope, ft/ft}}$$

$$= \frac{21.00 \text{ ft}}{1.5 \text{ ft/1000 ft}}$$

$$= (14 \text{ ft})(1000)$$

$$= 14{,}000 \text{ ft}$$

Note: If slope is not 1.5 ft/1000 ft over entire 14,000-foot section, length will have to be recalculated on basis of actual slopes and lengths until difference in elevation is reached.

Calculate the cross-sectional area of the sewer.

$$\text{Area, sq ft} = \frac{\pi}{4}(\text{Diameter, ft})^2$$

$$= \frac{\pi}{4}(2\text{ ft})^2$$

$$= 3.14\text{ sq ft}$$

Determine volume of 24-inch sewer 14,000 feet long.

$$\text{Volume, cu ft} = (\text{Area, sq ft})(\text{Length, ft})$$

$$= (3.14\text{ sq ft})(14{,}000\text{ ft})$$

$$= 43{,}982\text{ cu ft}$$

Note: If 24-inch sewer is not 14,000 feet long, volume will have to be calculated on basis of lengths and diameters of sewer in 14,000-foot section.

What portion of volume is available for storage? If flow is 2.5 MGD and capacity is 5.0 MGD, then sewer is flowing half full.

$$\frac{\text{Actual flow}}{\text{Capacity}} = \frac{2.5\text{ MGD}}{5.0\text{ MGD}}$$

$$= 1/2\text{ full}$$

Therefore, 1/2 volume of sewer is available for storage.

$$\text{Storage volume, cu ft} = (1/2)(\text{Volume, cu ft})$$

$$= (1/2)(43{,}982\text{ cu ft})$$

$$= 21{,}991\text{ cu ft}$$

Estimate time to fill sewer before manhole overflows.

$$\text{Time, hr} = \frac{(\text{Storage volume, cu ft})(7.5\text{ gal/cu ft})(24\text{ hr/day})}{(\text{Flow, gal/day})}$$

$$= \frac{(21{,}991\text{ cu ft})(7.5\text{ gal/cu ft})(24\text{ hr/day})}{2{,}500{,}000\text{ gal/day}}$$

$$= 1.58\text{ hr} \quad\text{or}\quad 1\text{ hr} + 0.58\text{ hr}\,(60\text{ min/hr})$$

$$= \underline{\underline{1\text{ hr }35\text{ min}}}$$

35. In the previous problem (number 34) we estimated a time of 1 hour and 35 minutes would be available before the lowest manhole would start overflowing. In actual practice we would watch the rate of rise of the water backing up to estimate how much time is available before the manhole would overflow. Estimate the expected rate of rise and calculate the actual rate of rise if water is rising 1.0 foot in 5 minutes.

Known	Unknown
From problem 34	Estimated rise, ft/min
Distance, ft = 21.00 ft	Actual rise, ft/min
Time, hr = 1.58 hr	
= 1 hr 35 min	
This problem	
Distance, ft = 1.0 ft	
Time, min = 5 min	

Calculate estimated rise.

$$\text{Est. rise, ft/min} = \frac{\text{Distance, ft}}{\text{Time, min}}$$

$$= \frac{21.0\text{ ft}}{(1.58\text{ hr})(60\text{ min/hr})}$$

$$= 0.22\text{ ft/min}$$

How long would we estimate it takes for the water to rise 1 foot?

$$\text{Est. rise, min/ft} = \frac{\text{Distance, ft}}{\text{Est. rise, ft/min}}$$

$$= \frac{1 \text{ ft}}{0.22 \text{ ft/min}}$$

$$= \underline{\underline{4.54 \text{ min}}} \text{ to rise 1 ft}$$

What is the actual rate of rise?

$$\text{Actual rise, ft/min} = \frac{\text{Distance, ft}}{\text{Time, min}}$$

$$= \frac{1.0 \text{ ft}}{5 \text{ min}}$$

$$= \underline{\underline{0.2 \text{ ft/min}}}$$

Note: Since the actual time for the water to rise 1 foot is 5 minutes and we estimated 4.5 minutes, we'll have a little longer than our estimated time of 1 hour and 35 minutes to get the lift station back on the line before the lowest manhole starts to overflow. Continue to watch the actual rate of rise for any changes.

K. Ventilation

36. What capacity blower (CFM) is required to ventilate a manhole 48 inches in diameter and 17-feet deep with 15 air changes per hour or one air change every 4 minutes?

Known		Unknown
MH Diameter, in	= 48 in	Blower Capacity, CFM
MH Depth, ft	= 17 ft	
Air change, min	= 4 min	

Determine volume of manhole.

MH Volume, cu ft = (Area, sq ft)(Depth, ft) Area $= \frac{\pi}{4} D^2$

$= \frac{\pi}{4} (4\text{ ft})^2(17\text{ ft})$

= 213.6 cu ft

Calculate blower capacity.

Blower Capacity, CFM $= \dfrac{\text{MH Volume, cu ft}}{\text{Air Change, min}}$

$= \dfrac{213.6\text{ cu ft}}{4\text{ min}}$

= 53.4 cu ft/min

or at least 55 CFM

L. Costs

37. Estimate the total cost and cost per linear foot of a sanitary sewer construction project. The project consists of 1550 lineal feet of 10-inch VCP with four manholes equally spaced. The average depth of the trench is 9 feet and the average width is 3 feet (including excavation for manholes). Estimated costs are as follows:

Excavation and backfill	$14.00 per linear foot
Pipe cost	$ 2.25 per linear foot
AC paving	$ 1.60 per square foot
Manholes, complete	$600.00 each

Known	Unknown
Costs given above	Total Cost, $
Length, ft = 1550 ft	Cost/ft, $/ft
Diameter, in = 10 in	
Depth, ft = 9 ft	
Width, ft = 3 ft	

Determine excavation and backfill cost.

Cost, $ = (Cost, \$/ft)(Length, ft)

= (\$14.00/ft)(1550 ft)

= \$21,700

Determine pipe cost.

Cost, $ = (Pipe cost, \$/ft)(Length, ft)

= (\$2.25/ft)(1550 ft)

= \$3,487.50

Determine paving cost.

Cost, $ = (Paving cost, $/sq ft)(Length, ft)(Width, ft)

= ($1.60/sq ft)(1550 ft)(3 ft)

= $7440.

Determine manhole cost.

Cost, $ = (MH cost, $/MH)(Number of MH)

= ($600/MH)(4 MH)

= $2400.

Determine total cost of project.

Exc. and backfill = $21,700.00

Pipe = 3,487.50

Paving = 7,440.00

MH = 2,400.00

Total Cost = $35,027.50

Determine cost per linear foot.

$$\text{Cost, \$/ft} = \frac{\text{Total Cost, \$}}{\text{Length, ft}}$$

$$= \frac{\$35{,}027.50}{1550\text{ ft}}$$

$$= \underline{\underline{\$22.60/\text{ft}}}$$

38. A review of previous records indicated that a certain repair job could be completed by a crew of two workers in 20 hours. How long would it take a crew of five workers to complete a similar job and what would be the labor costs at $5.00 per hour?

Known		Unknown
Two workers can do job in 20 hours.		Time for 5 workers
Labor	= $5.00/hour	Labor costs

Determine worker-hours to do the job.

Time, worker-hours = (Number of workers)(Time, hours)

= (2 workers)(20 hours)

= 40 worker-hours

Calculate time for 5 workers to do job.

$$\text{Time, hours} = \frac{\text{Time, worker-hours}}{\text{Number of workers}}$$

$$= \frac{\text{40 worker-hours}}{\text{5 workers}}$$

$$= \underline{\underline{\text{8 hours}}}$$

Estimate labor costs.

Labor cots, $ = (Time, worker-hours)(Labor, $/worker-hour)

= (40 worker-hours)($5/worker-hour)

= $\underline{\underline{\$200}}$

M.10 METRIC SYSTEM[4]

The two most common systems of weights and measures are the English system and the Metric system. Of these two, the Metric system is the more popular with most of the nations of the world. The reason for this is that the Metric system is based on a system of tens and is therefore easier to remember and easier to use than the English system. Even though the basic system in this country is the English system, the scientific community uses the Metric system almost exclusively. Although many organizations have urged, for good reason, that the United States switch to the Metric system, the English system still is the standard system of measurement in the United States.

In order to study the Metric system, one must know the meanings of the terminology used. Following is a list of Greek and Latin prefixes used in the Metric system.

PREFIXES USED IN THE METRIC SYSTEM

Prefixes	Meaning
Milli	1/1000 or 0.001
Centi	1/100 or 0.01
Deci	1/10 or 0.1
Unit	1
Deka	10
Hecto	100
Kilo	1000

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[4] Also read "Welcome to METRIC Wastewaterland", and "The Metric System Leads to Easier Arithmetic", The Bulletin, CWPCA, Volume 12, No. 2, October, 1975, California Water Pollution Control Association, 127 N. Madison, Suite 304, Pasadena, CA 91101. Price $1.20 each.

M.100 Measures of Length

The basic measure of length is the meter.

1 kilometer (km) = 1000 meters (m)

1 meter (m) = 100 centimeters (cm)

1 centimeter (cm) = 10 millimeters (mm)

Kilometers are usually used in place of miles, meters are used in place of feet and yards, centimeters are used in place of inches, and millimeters are used for fractions of an inch.

LENGTH EQUIVALENTS

1 kilometer	=	0.621 mile	1 mile	=	1.64 kilometers
1 meter	=	3.28 feet	1 foot	=	0.305 meter
1 meter	=	39.37 inches	1 inch	=	0.0254 meter
1 centimeter	=	0.3937 inch	1 inch	=	2.54 centimeters
1 millimeter	=	0.0394 inch	1 inch	=	25.4 millimeters

NOTE: The above equivalents are reciprocals. If one equivalent is given, the reverse can be obtained by division. For instance, if one meter equals 3.28 feet, one foot equals 1/3.28 meter, or 0.305 meter.

M.101 Measures of Capacity or Volume

The basic measure of capacity in the Metric system is the liter. For measurement of large quantities the cubic meter is sometimes used.

1 kiloliter (kl) = 1000 liters (l) = 1 cu meter (m^3)

1 liter (l) = 1000 milliliters (ml)

Kiloliters, or cubic meters, are used to measure capacity of large storage tanks or reservoirs in place of cubic feet or gallons. Liters are used in place of gallons or quarts. Milliliters are used in place of quarts, pints, or ounces.

CAPACITY EQUIVALENTS

1 kiloliter = 264.2 gallons	1 gallon = 0.003785 kiloliter
1 liter = 1.057 quarts	1 quart = 0.946 liter
1 liter = 0.2642 gallon	1 gallon = 3.785 liters
1 milliliter = 0.0353 ounce	1 ounce = 29.57 milliliters

M.102 Measures of Weight

The basic unit of weight in the Metric system is the gram. One cubic centimeter of water at maximum density weighs one gram, and thus there is a direct, simple relation between volume of water and weight in the Metric system.

1 kilogram (kg) = 1000 grams (gm)

1 gram (gm) = 1000 milligrams (mg)

1 milligram (mg) = 1000 micrograms (μg)

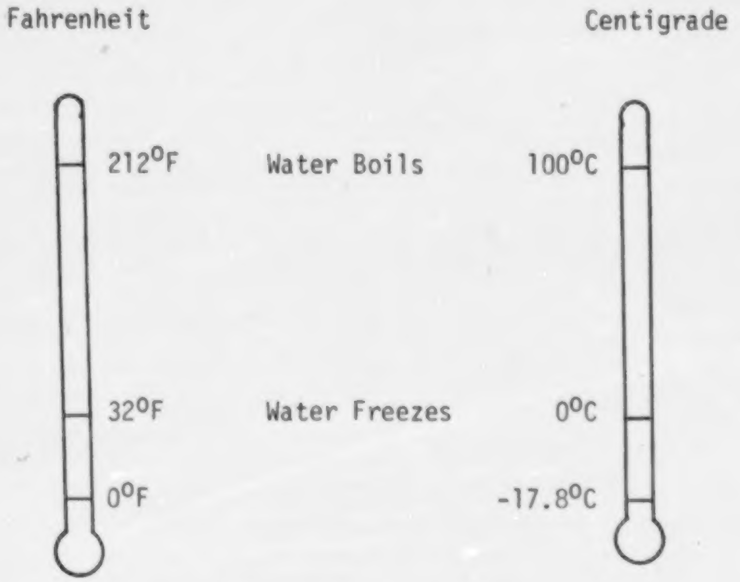
Grams are usually used in place of ounces, and kilograms are used in place of pounds.

WEIGHT EQUIVALENTS

1 kilogram = 2.205 pounds	1 pound = 0.4536 kilogram
1 gram = 0.0022 pound	1 pound = 453.6 grams
1 gram = 0.0353 ounce	1 ounce = 28.35 grams
1 gram = 15.43 grains	1 grain = 0.0648 gram

M.103 Temperature

Just as the worker should become familiar with the Metric system, he should also become familiar with the centigrade (Celsius) scale for measuring temperature. There is nothing magical about the centigrade scale -- it is simply a different size than the Fahrenheit scale. The two scales compare as follows:


Fahrenheit
Centigrade
212°F
Water Boils
100°C
32°F
Water Freezes
0°C
0°F
-17.8°C

The two scales are related in the following manner:

$$\text{Fahrenheit} = ({}^{\circ}C \times 9/5) + 32^{\circ}$$

$$\text{Centigrade} = ({}^{\circ}F - 32^{\circ}) \times 5/9$$

Example: Convert 20° Centigrade to Fahrenheit.

$$F = ({}^{\circ}C \times 9/5) + 32^{\circ}$$

$$F = (20^{\circ} \times 9/5) + 32^{\circ}$$

$$F = \frac{180^{\circ}}{5} + 32^{\circ}$$

$$= 36^{\circ} + 32^{\circ}$$

$$= 68^{\circ}F$$

Example: Convert $-10^{\circ}C$ to ${}^{\circ}F$.

$$F = (-10^{\circ} \times 9/5) + 32^{\circ}$$

$$F = -90^{\circ}/5 + 32^{\circ}$$

$$= -18^{\circ} + 32^{\circ}$$

$$= 14^{\circ}F$$

Example: Convert $-13^{\circ}F$ to ${}^{\circ}C$.

$$C = ({}^{\circ}F - 32^{\circ}) \times \frac{5}{9}$$

$$C = (-13^{\circ} - 32^{\circ}) \times \frac{5}{9}$$

$$C = -45^{\circ} \times \frac{5}{9}$$

$$C = -5^{\circ} \times 5$$

$$C = -25^{\circ}C$$

Another method of converting degrees Fahrenheit to degrees Centigrade (Celsius) or vice versa is as follows:

1. Add 40^0
2. Multiply by 5/9 or 9/5
3. Subtract 40^0

Example: Convert 20^0C to ^0F

1. Add 40^0

$$^0F = 20^0C + 40^0$$
$$= 60^0$$

2. Multiply by 9/5

$$^0F = \frac{(60^0)(9)}{5}$$
$$= 108^0$$

3. Subtract 40^0

$$^0F = 108^0 - 40^0$$
$$= 68^0F$$

Checks with other method.

Example: Convert -13^0F to ^0C.

1. Add 40^0

$$^0C = -13^0F + 40^0$$
$$= 27^0$$

2. Multiply by 5/9.

$$^0C = \frac{(27^0)(5)}{(9)}$$
$$= 15^0$$

3. Subtract 40^0

$$^0C = 15^0 - 40^0$$
$$= -25^0C$$

Checks with other method.

M.104 Milligrams per Liter

Milligrams per liter (mg/l) is a unit of expression used in laboratory and scientific work to indicate very small concentrations or dilutions. Since wastewater contains small concentrations of dissolved substances and solids and since small amounts of chemical compounds are sometimes used in wastewater treatment processes, the term milligrams per liter is also common in treatment plants. It is a weight/volume relationship.

As previously discussed:

1000 liters = 1 cubic meter = 1,000,000 cubic centimeters

Therefore

1 liter = 1000 cubic centimeters

Since one cubic centimeter of water weighs one gram,

1 liter of water = 1000 grams or 1,000,000 milligrams.

$$1\ \frac{\text{Milligram}}{\text{liter}} = \frac{1\ \text{milligram}}{1{,}000{,}000\ \text{milligrams}} = \frac{1\ \text{part}}{\text{million parts}} = \begin{matrix}\text{1 part per}\\ \text{million (ppm)}\end{matrix}$$

Milligrams per liter and parts per million (parts) may be used interchangeably as long as the liquid density is 1.0 gm/cu cm or 62.43 lb/cu ft. A concentration of 1 milligram/liter (mg/l) or 1 ppm means that there is 1 part of substance by weight for every 1 million parts of water. A concentration of 10 mg/l would mean 10 parts of substance per million parts of water.

To get an idea of how small 1 mg/l is, divide the numerator and denominator of the fraction by 10,000. This, or course, does not change its value since 10,000 ÷ 10,000 is equal to one.

$$1\ \frac{\text{mg}}{\text{l}} = \frac{1\ \text{mg}}{1{,}000{,}000\ \text{mg}} = \frac{1/10{,}000\ \text{mg}}{1{,}000{,}000/10{,}000\ \text{mg}} = \frac{0.0001\ \text{mg}}{100\ \text{mg}} = 0.0001\%$$

Therefore, 1 mg/l is equal to one ten-thousandth of a percent, or

1% is equal to 10,000 mg/l

To convert mg/l to %, move the decimal point four places or numbers to the left.

Working problems using milligrams per liter or parts per million is a part of everyday operation in most wastewater treatment plants.

M.11 SUMMARY OF FORMULAS

M.110 Length

LENGTH OR CIRCUMFERENCE OF A CIRCLE:

Length, ft = 3.14 (Diameter, ft)

M.111 Area

RECTANGLE:

Area, sq ft = (Length, ft)(Width, ft)

TRIANGLE:

Area, sq ft = (1/2)(Base,ft)(Height,ft)

CIRCLE:

Area, sq ft = 0.785 (Diameter, ft)^2

CYLINDER (wall):

Area, sq ft = 3.14 (Diameter, ft)(Height, ft)

SPHERE:

Area, sq ft = 3.14 (Diameter, ft)^2

M.112 Volume

RECTANGLE:

Volume, cu ft = (Length, ft)(Width, ft)(Height, ft)

CYLINDER:

$$\text{Volume, cu ft} = 0.785\ (\text{Diameter, ft})^2\ (\text{Height, ft})$$

SPHERE:

$$\text{Volume, cu ft} = 0.524\ (\text{Diameter, ft})^3$$

M.113 Velocity and Flow

$$\text{Velocity, ft sec} = \frac{\text{Distance Traveled, ft}}{\text{Time, sec}}$$

or

$$\text{Velocity, ft/sec} = \frac{\text{Flow Rate, cu ft/sec}}{\text{Cross-Sectional Area, sq ft}}$$

$$\text{Ave. flow, MGD} = \frac{\text{Sum of daily flows, MGD}}{\text{Number of daily flows}}$$

M.114 Slope or Grade

$$\text{Grade, ft/ft} = \frac{\text{Rise, ft}}{\text{Run, ft}}$$

M.115 Chemical Doses

Chlorine Demand, mg/l = Chlorine Dose, mg/l - Chlorine Residual, mg/l

Chlorine Feed Rate, lbs/day = (Dose, mg/l)(Flow, MGD)(8.34 lbs/gal)

Chemicals, lbs = (Concentration, mg/l)(Volume, MG)(8.34 lbs/gal)

M.116 Excavation and Paving

$$\text{Trench Width at Top, ft} = \text{Base, ft} + (2)\frac{(\text{Depth, ft})}{\text{Side Slope}}$$

$$\text{Where Side Slope} = \frac{\text{Rise, ft}}{\text{Run, ft}}$$

M.117 Electricity

Ohm's Law $E = IR$

or

$$\text{EMF, Volts} = (\text{Current, amps})(\text{Resistance, ohms})$$

$$\text{Power, watts} = (\text{E, volts})(\text{I, amps})$$

$$\text{Power, watts} = (\text{I, amps})^2(\text{R, ohms})$$

$$\text{Motor Output, watts} = (\text{Power, watts})(\text{Power factor})(\text{Motor efficiency})$$

M.118 Pumps

$$\text{Water, HP} = \frac{(\text{Flow, gpm})(\text{H, ft})}{3960}$$

$$\text{Brake, HP} = \frac{(\text{Flow, gpm})(\text{H, ft})}{(3960)(E_p)}$$

$$\text{Motor, HP} = \frac{(\text{Flow, gpm})(\text{H, ft})}{(3960)(E_p)(E_m)}$$

$$\text{Efficiency, \%} = \frac{\text{Output}}{\text{Input}} \times 100\%$$

M.119 Storage Tanks, Wet Wells and Storm Water Storage Basins

$$\text{Fill time, hrs} = \frac{(\text{Tank Volume, cu ft})(7.5\ \text{gal/cu ft})(24\ \text{hr/day})}{\text{Flow, gal/day}}$$

M.12 CONVERSION TABLES

Tables in this section were taken from Water and Wastewater Engineering, Volume 1, *Water Supply and Wastewater Removal*, by G. M. Fair, J. C. Geyer, and D. A. Okun, John Wiley & Sons, Inc., New York, 1966. Price $19.75. The tables are also found in Volume 2, *Water Purification and Wastewater Treatment and Disposal*, 1968. Price $22.00.

The American and English weights and measures referred to in this book are alike except for the gallon. The United States gallon is employed. The United States billion, which equals 1000 million, is also employed.

LENGTH

Miles	Yards	Feet	Inches	Centimeters
1	1760	5280	--	--
--	1	3	36	91.44
--	--	1	12	30.48
--	--	--	1	2.540

1 m = 100 cm = 3.281 ft = 39.37 in

AREA

Square Miles	Acres	Square Feet	Square Inches	Square Centimeters
1	640	--	--	--
--	1	43,560	--	--
--	--	1	144	929.00
--	--	--	1	6.452

1 sq m = 10.76 sq ft

VOLUME

Cubic Feet	Imperial Gallons	U.S. Gallons	Cubic Inches	Liters
1	6.23	7.481	1728	28.32
--	1	1.2	277.4	4.536
--	--	1	231	3.785
--	--	--	57.75	0.946
--	--	--	61.02	1

1 cu m = 35.31 cu ft = 264.2 gal

1 Imperial (UK) gal weighs 10 lb
1 cu ft of water weighs 62.43 lb
1 cu m = 10^3 1 and weighs 1000 kg
1 US gal weighs 8.34 lb
1 cu m weighs 2283 lb

VELOCITY

Miles per Hour	Feet per Second	Inches per Minute	Centimeters per Second	Kilometers per Hour
1	1.467	1056	--	1.609
--	1	720	20.48	--
--	--	1	0.423	--

TIME

Days	Hours	Minutes	Seconds
1	24	1440	86,400
--	1	60	3,600
--	--	1	60

WEIGHT

Tons	Pounds	Grams	Grains	Metric Tons
1	2000	--	--	0.9078
--	1	454	7000	--
--	--	1	15.43	--

1 long ton = 2240 lb

1 ppm = 1 mg/1 = 8.34 lb per MG

DISCHARGE

Cubic Feet per Second	Million Gallons Daily	Gallons per Minute
1	0.6463	448.8
1.547	1	694.4

1 in per hour per acre = 1.008 cfs

1 cu m/sec = 22.83 MGD = 35.32 cfs

PRESSURE

Pounds per Square Inch	Feet of Water	Inches of Mercury
1	2.307	2.036
0.4335	1	0.8825
0.4912	1.133	1

1 atm = 14.70 psia = 29.92 in. Hg =

33.93 ft water = 76.0 cm Hg

POWER

Kilowatts	Horsepower	Foot-Pounds per Second	Kilogram-Meters per Second
1	1.341	737.6	102.0
0.7457	1	550	76.04

WORK AND ENERGY

Kilowatt-Hours	Horsepower-Hours	British Thermal Units
1	1.341	3412
0.7457	1	2544

TEMPERATURE

Degree Fahrenheit = $32 + \frac{9}{5} \times$ Degrees Centigrade

0	5	10	15	20	25	30	35	40	45	50	55	60	C
32	41	50	59	68	77	86	95	104	113	122	131	140	F

DENSITY OF WATER

1 gram/cm^3 = 62.43 lb/cu ft

M.13 ADDITIONAL READING

1. Mathematics for Water and Wastewater Treatment Plant Operators, Book 1 - Fundamentals and Book 2 - Advanced, by Joanne Kirkpatrick, Ann Arbor Science Publishers, Inc., Post Office Box 1425, Ann Arbor, Michigan 48106. Price, $17.50 each.

2. "Basic Mathematics for Treatment Plant Operators" by William Crooks, Chapter 15 in Operation of Wastewater Treatment Plants, Kenneth D. Kerri, California State University, Sacramento, 6000 Jay Street, Sacramento, California 95819. Price for 17 chapter manual, $25.00.

M.14 PRACTICE PROBLEMS

1. Estimate the number of people contributing to a flow of 400,000 gallons per day in an 8-inch sewer. Assume a population flow equivalent of

   a. 100 gpcd
   b. 85 gpcd.

2. A large cannery discharges 8 MGD during the peak canning season. What is the hydraulic population equivalent using 100 gpcd?

3. A subdivision serves 1500 people. What is the expected average daily flow in MGD assuming 100 gpcd?

4. A colored dye is dumped into a manhole. The dye first appears 4 minutes later in a manhole 750 feet downstream and disappears 6 minutes after first dumped into manhole. Estimate the velocity of flow in the sewer in

   a. ft/min
   b. ft/sec.

5. A float required 3 minutes and 28 seconds to travel 428 feet between two manholes. Estimate the velocity of the wastewater in the sewer assuming the surface velocity (float velocity) is 12 percent higher than the average velocity.

6. Estimate the flow in a 15-inch sewer flowing full if the average velocity is 2.6 ft/sec.

   a. cfs
   b. MGD
   c. GPM

1704

7. Calculate the flow in a 6-inch sewer flowing half full when the average velocity is 2.3 ft/sec.

   a. cfs
   b. MGD

8. An 8-inch sewer carries a flow of 0.5 MGD when flowing full. What is the average velocity?

9. A sewer must carry a maximum flow of 1 MGD at a velocity of 2 ft/sec. What is the diameter? Select the next smaller nominal diameter so the actual flow will exceed 2 ft/sec and assume adequate grade is available to achieve the necessary velocity.

10. What is the average daily flow during August for a lift station given the following flow totalizer readings:

    8:00 a.m. August 1 2,023,761,405 gallons

    8:00 a.m. September 1 2,232,109,478 gallons

    There are 31 days in August.

11. Estimate the average daily flow on Mondays for a lift station with the following readings:

Date	Flow, MG
Aug. 4	1.75
Aug. 11	1.78
Aug. 18	1.63
Aug. 25	1.72

12. A piece of pipe is 17 feet long and is to be cut into 5 equal pieces. Each piece will be ____ ft ____ inches long.

13. A piece of pipe is 11 feet, 6 inches long and is to be cut into 4 equal pieces. Each piece will be ____ ft ____ inches long.

14. One side of the grounds for a lift station is 100 feet long. How many trees will be required if the trees are to be 25 feet apart with a tree at each end? Hint: Draw a sketch.

15. How many feet will a 12-inch sewer rise in 420 feet when laid on a grade of 0.009?

16. A trench drops 13 feet in 828 feet, what is the grade in ft/ft and in percent?

17. How many feet will a 6-inch sewer drop in 385 feet when laid on a 0.7% grade?

18. Determine the slope on a 10-inch sewer that is 367 feet long if the invert elevation at the downstream manhole is 77.23 feet and upstream invert elevation is 81.39 feet.

19. An 8-inch sewer has been televised and the footage meter between two manholes indicates the distance is 381 feet. An actual field measurement verifies the distance shown on the plans as 392 feet.

    a. What is the percent error in the length?

    b. If the TV camera was pulled from the upstream to the downstream manhole, what is the distance from each manhole to a protruding tap at a distance of 238 feet?

20. A 6-inch sewer 383 feet long is given a water leak test. The downstream manhole is plugged where the line enters the manhole and there are no service lines connected to the test line. At 9:00 a.m. on Thursday morning, the 36-inch upstream manhole was filled to the bottom of the cone. At 9:00 a.m. on Friday morning, the water had dropped 3 feet 8 inches. Calculate the leakage from the sewer in terms of gallons per day per inch of sewer diameter per mile of sewer.

21. A section of sewer in a swampy area is going to be televised in an attempt to locate and identify the causes of excessive infiltration. The distance to be televised measures 2 13/16 inch and the scale is 1 inch equals 800 feet. How long (in feet) is the line to be televised?

22. How many square feet surface area in a maintenance corporation yard that measures 2 3/4 inch by 5 3/8 inch on a drawing whose scale is 1 inch equals 40 feet?

23. A new manhole has been installed 254 feet from an existing manhole. How far would this new manhole be located from the old manhole on a map with a scale of 1 inch equals 40 feet?

24. Estimate the chlorine demand of a wastewater if the chlorinator is dosing at a rate of 20 mg/l and a residual of 0.4 mg/l of chlorine remains in the wastewater 30 minutes later.

25. If a wastewater is to be dosed at a rate of 10 mg/l and the flow is 2 MGD, what should be the chlorinator setting in pounds of chlorine per day?

26. A chlorinator is set to dose at a rate of 100 pounds of chlorine per day. What is the dose in mg/l when the flow is 0.8 MGD?

27. How many pounds of chemicals are required for root control if a concentration of 300 mg/l is recommended by the manufacturer to dose a 6-inch sewer 326 feet long?

28. Ten pounds of chemicals could produce what concentration (mg/l) if perfectly mixed in a 10-inch sewer 407 feet long?

29. A trench 2.5 feet wide, 6.5 feet deep and 65 feet long is to be filled with select backfill.

    a. How many cubic feet of backfill required?
    b. How many cubic yards of backfill?
    c. How many 5-cubic yard dump truck loads?
    d. How many tons of backfill if the backfill weighs 130 lbs/cu ft?

30. How many cubic yards of AC paving material will be required to pave a maintenance yard 100 feet wide and 200 feet long if the paving material is to be 4 inches thick?

31. How wide is a sewer trench at the top if the trench is 3-feet wide at the bottom, 9 feet deep, and the walls are sloped at 1-foot horizontal to 1-foot vertical?

32. Prepare a sewer grade (cut) sheet for a sewer laid on a 0.7% grade with the given stake elevations and invert grade.

Station	Stake Elevation	Invert Grade	Cut
0+00	57.28	50.00	
0+50	57.91		
1+00	58.13		
1+50	58.55		
2+00	59.67		
2+48	60.03		

33. A 12-volt battery operates a radio with a 3.5-ohm resistance. What amp fuse is necessary?

34. A pump motor is supplied with 440 volts and draws 35 amps. What is the horsepower output of the motor if the power factor is 0.85 and the motor efficiency is 89%?

35. A 40-ohm resistor requires a current of 11 amps. How many watts will the resistor draw?

36. Determine the water horsepower delivered by a pump if the flow is 500 GPM and the total dynamic head is 58 feet.

37. What is the total dynamic head that a pump can overcome when the flow is 2 cfs (cubic feet per second) and the delivered water horsepower is 10 horsepower?

38. What flow (GPM) could a 6 horsepower pump deliver against a total dynamic head (TDH) of 48 feet under these flow conditions? NOTE: TDH depends on flow and increases with flow. Usually a flow is known, the TDH is determined, and a pump to meet these requirements is selected.

39. How efficient is a pump if the brake horsepower is 8 hp and the water horsepower is 5.8 hp?

40. If a pump motor draws 3800 watts and the water horsepower from the pump is 3.5 hp, what is the overall efficiency of the system?

41. A variable-speed pump delivers 500 GPM at a speed of 1200 rpm. What should be the speed to deliver 550 GPM?

42. Estimate the flow into a wet well 5-feet wide and 8-feet long if the level rises 3.5 feet in 6 minutes.

43. Estimate the pumping rate of a pump when water is flowing into a wet well at 500 GPM and the wet well water level is dropping 0.8 feet in 3 minutes. The wet well is 5 feet by 5 feet.

44. Estimate the total cost and cost per linear foot of a sanitary sewer construction project. The project consists of 378 feet of 6-inch sewer and one manhole. Costs are estimated as follows:

Excavation and backfill	\$ 12.00 per linear foot
Pipe cost	\$ 2.00 per linear foot
Manhole, complete	\$650.00 each

45. Estimate the time for a four-worker crew to complete a particular job and the labor costs at $6 per hour. Previous records indicate that the job could be completed by a crew of three workers in 36 hours.

46. The temperature of wastewater in a sewer is reported as 12°C. What is the temperature in degrees Fahrenheit?

47. The temperature of wastewater is measured as 75°F. What is the temperature in degrees Celsius (Centigrade)?

M.15 ANSWERS TO PRACTICE PROBLEMS

1. a. 4000 persons
   b. 4706 persons

2. 80,000 persons

3. 0.150 MGD

4. a. 150 ft/min
   b. 2.5 ft/sec

5. 1.81 ft/sec

6. a. 3.19 cfs
   b. 2.06 MGD
   c. 1433 GPM

7. a. 0.23 cfs
   b. 0.15 MGD

8. 2.2 ft/sec

9. 12 in

10. 6.72 MGD

11. 1.72 MGD

12. 3 ft 4 13/16 in

13. 2 ft 10 1/2 in

14. 5 trees

15. 3.78 ft

16. 0.0157 ft/ft or 1.57%

17. 2.70 ft

18. 0.0113 ft/ft or 1.13%

19. a. 2.8%
    b. 245 ft from upper
       147 ft from lower

20. 446 gpd/in/mi

21. 2250 ft

22. 23,650 sq ft

23. 6 3/8 in

24. 19.6 mg/l

25. 170 lbs/day

26. 15 mg/l

27. 1.2 lbs

28. 722 mg/l

29. a. 1056 cu ft
    b. 39 cu yd
    c. 8 truck loads
    d. 68.6 tons

30. 247 cu yds

31. 21 ft

32.

Station	Invert Grade	Cut
0+00	50.00	7.28
0+50	50.35	7.56
1+00	50.70	7.43
1+50	51.05	7.50
2+00	51.40	8.27
2+48	51.74	8.29

33. 3.5 amps

34. 15.6 hp

35. 4840 watts

36. 7.32 hp

37. 44 ft

38. 495 GPM

39. 72.5%

40. 68.7%

41. 1320 rpm

42. 175 GPM

43. 550 GPM

44. \$5942
\$15.72/ft

45. 27 hours
\$162

46. 53.6°C

47. 23.9°C